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HADRIAN'S VILLA AT TIVOLI.*

THE Sabine Mountains are full of interest to the archæologist and the lover of the picturesque. This chain of the Apennines descends rapidly to the plain. The mountains are of limestone, so that they are very different in appearance from the volcanic Alban Mountains which bound the Roman Campagna on the southeast. Tivoli, a favorite summer resort of the Romans in the time of Horace, is, of course, the most frequented place in the Sabine chain, and is situated about 18 miles from Rome by railway. At a small place 15½ miles from Rome the guard calls out "Villa Adriana," and no well-read traveler would think of continuing his journey to Tivoli without making a stop to visit the celebrated Villa of Hadrian, which is one of the most interesting monuments of antiquity.

The Villa of Hadrian, which with its magnificent grounds occupying an area of several square miles, dates from the last years of the reign of Hadrian, who died in A. D. 138. It was intended as a souvenir of travel. His biographer Spartian says: "Hadrian created in his villa at Tivoli a marvel of architecture and landscape gardening; to its different parts he assigned the names of celebrated buildings and localities." When first built it must have been more like a town than a villa, an opinion confirmed by the number of buildings having the appearance of dwelling houses, revealed by the excavations of 1880. After the death of the Emperor Hadrian little use seems to have been made of the gigantic construction, and it does not again appear in history until in 544 A. D. it served Totila as a fortress. During the following centuries the ruins afforded valuable building materials. In the sixteenth century a profitable search for works of art was instituted here, and the ruins afforded an almost inexhaustible series of works of art, including the mosaic known as Pliny's Doves and the Faun in *rosso antico*, now in the Capitoline Museum. It is also probable that the Venus de Medici came from this villa, with various other statues whose *provenance* is now forgotten. It is almost impossible to read any account of ancient sculpture without finding some reference to Hadrian's Villa. It was by the orders of Hadrian himself that a change was effected in the law concerning the portraits of private individuals, and this change led to the fashion of having portraits in statuary in the houses of all the noble and opulent citizens. In the villa at Tivoli Hadrian placed the statues and busts of all his living and deceased friends.

Unfortunately, the destruction of the buildings kept pace with the search for art treasures until the Italian government purchased the villa from the Braschi family in 1871. Between 1870 and 1882 the greater part of the immense area was uncovered, but unfortunately the lovely carpet of shrubs and flowers which made such an effective background to the ruins has been swept away.

Although the ruins seem confused to the visitor, still with the aid of a plan like that which we give, some idea of the magnitude of the scheme may be gained. The natural inequalities and undulations of the site furnished admirable motives for the architects and landscape gardeners employed by the Emperor. When the shortness of the time during which the works were under way is considered, it will be seen that it was necessary for the laborers to be directed by men of unerring taste. This does not appear to have been the case, as Castellan, a French traveler of the last century, who visited the ruins when they were much more perfect than they are to-day, claims that the buildings were neither skillfully nor tastefully disposed. A reference to the plan will show the incongruous juxtaposition of circular and rectangular edifices. In construction the main walls are of concrete faced with mixed brick and opus reticulatum, and they were once covered with Oriental marbles and crowded with fine Greek and Græco-Roman sculpture. The floors were of marble and glass mosaic, and the vaulting was in many cases elaborately painted in encaustic.

We present a plan and some views of the existing ruins of Hadrian's Villa. The entrance gate and the avenue of trees occupy the site of the porticus which leads to the Greek Theater, one of the three which formerly existed in the villa. Among other notable features of the villa are the Marine Theater, so called from the discovery of the mosaic pavement representing marine monsters. The plan of the building is not, however, adapted for theatrical purposes. It was entirely excavated in 1873. A circular area was inclosed by a porticus of marble columns supporting a frieze ornamented with marine subjects of fine workmanship; several of these columns have been re-erected. Between this porticus and the island in the center runs a deep channel lined with beautiful marble slabs. It is supposed from this that it was probably intended for a swimming bath. The island is reached by two swinging bridges opening into vestibules which led to a semicircular hall adorned with columns. Beyond were the atrium, and the triclinum with bedrooms on each side. The beautiful statue of the Faun in *rosso antico*, now in the Capitoline Museum, was discovered here.

To the east of the Marine Theater at a somewhat higher elevation is a rectangular court, the left side of which is occupied by the so-called library, which still remains intact with the exception of the upper stories. There are hardly any ruins which are better adapted to show the Roman methods of building construction than this library. Some portions of the villa are very extensive; thus the lofty reticulated wall of the porticus, marked *Poikile* on the plan, is nearly 600 feet in length, and is perhaps the most remarkable of all the ruins of Hadrian's Villa. The form of the building is that of a stadium raised on an artificial platform of masonry with vaulted chambers, which are now supposed to have been occupied by slaves and soldiers. Near this construction is the thermæ, with remains of tasteful stucco ornamentation. To the left as we leave the thermæ opens the valley of Canopus, which is actually cut out of tufa rock. Hadrian constructed the canal with the temple in the background, and also numerous small chambers, where he caused festivals to be celebrated in the Egyptian manner. Some of the Egyptian superstitions having been introduced into Italy about this time, they were mixed up with the existing forms of worship, and the gods of the Nile were admitted among those of the Romans. The example of the capital was soon followed by the smaller communities, and as the new worship was extended over the whole empire, a great demand arose for statues and other symbols of Egyptian deities and ceremonies. At the end of the valley is a well-preserved recess with a fountain, beyond which was a system of subterranean halls terminating in a cella with a statue of Serapis. Many of the most celebrated works of art now in

ENTRANCE TO HADRIAN'S VILLA.

MARINE THEATER, HADRIAN'S VILLA.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

the Vatican were discovered here. From the plan it will be seen that days may be spent in exploring this wonderful collection of ruins, which are the most extensive in all Italy.

HOW DID THE ROMANS HEAT THEIR LIVING ROOMS AND BATHS?

Since practical technicians have become active in the domains of archæology and history of civilization, together with the philologist, the estheticizing philosopher and artist, these studies, which threatened to degenerate into grammatical pettifoggery and euphonious phrase-mongering, are permeated by a new, refreshing influence, which it is true made it necessary to discard many a deep-rooted prejudice. In Krell's "Old Roman Heating Methods" the hitherto existing opinion of the learned archæologists regarding the *hypocausts** are refuted with the accuracy of an expert—Krell is a heating engineer. Krell proves that the fuel in the old Roman living rooms was almost exclusively charcoal, which explains the large number of charcoal mounds in the Hochtaunus and along the Pfahlgraben.

The living rooms were heated with charcoal pans, and probably this is still done to-day by a large majority of people. Carefully conducted experiments showed that in burning charcoal in open pans without grate and with a low burning layer, the dangerous carbonic oxide is not generated in any appreciable and injurious quantity.

The method of the ancients in using the frequently very elaborate charcoal pans for heating was very economical as well as esthetic, for, as Krell proves by a very accurate computation, a charcoal pan with a burning surface of 1.88 meters would be sufficient to heat, for example, the Egidien Church at Nuremberg, which seats more than 2,000 people. Another advantage was that the heat could be easily regulated and a chimney with the attending cost and inconveniences was unnecessary.

Charcoal fires without grate and flue were also used in the Roman baths. Characteristic of such arrangement is the single bath heating device at a villa in Boscoreale, near Pompeii. The upright boiler is heated from a furnace. On the other side of the stone wall is the bath tub of masonry and lined with marble. A semi-cylindrical kettle communicates with the water in the tub and extends into the hearth so that the bath water from the boiler does not cool off too quickly. The subterranean hollow space with the columns underneath the tub, etc., was heretofore in similar constructions regarded as the "hypocaustum."

Heretofore the opinion of the archæologists has been that a wood fire built in a hearth would heat the water in the masonry tub without being heated in the boiler, simply by means of the hot air circulating in the hypocausts. In all "finds" made the cellaring was immediately pronounced to be a hypocaust and the room above it a bath. This view, however, is absolutely untenable. The stone or masonry bottom of the bath tubs is too thick to allow the heat from the cellars to penetrate. In case of a direct fire cracks and fissures would have appeared causing the tub to leak. Furthermore, the heating surfaces formed by the subterranean space would be too large to effect even with the use of smokestacks, which would have to have had the height of our factory chimneys, an appreciable heating of the bath water. Besides, the hypocausts lack every arrangement for the necessary draught, and of chimneys there is no trace. It must also be considered that neither in the hypocausts nor in the tubulations in the walls, which, according to the prevailing opinion, were also designed for heating, not a particle of ashes or soot has been found, although there were no orifices for cleaning in the floors.

The columns of the hypocausts are nowhere provided with fireproof plastering (generally loam) nor made of fireproof stone, hence can never have been exposed to naked fire, and the tubulations (hollow spaces in the walls) do not communicate with the hypocausts and are also closed at the roof.

Sometimes, however, flues for the escape of smoke, draughts, traces of ashes and fireproof plastering are found (e. g., in the Roman castle at Saalburg) and in this case the term "hypocaust hot-air heating" is admissable. Here the hot air entered the living rooms direct, with proper ventilation and regulation from various apertures in the flooring. In baths this kind of arrangement is never met with. For heating by hot air charcoal was also employed. Naked wood fire was applicable only in the very primitive canal system which is found in smaller castles (Saalburg), where the putting up of charcoal mounds was too laborious or not warranted by the importance of the place in question. In these styles which likewise do not occur in thermæ the floor was traversed by canals covered with thin plates which alone served to heat the room, while the smoke and gases escaped in a very uneconomical manner it is true through chimneys erected in the corners as in the case of the Roman castle Saalburg.

The question arises: How could such a radically wrong and physically impossible notion regarding the hypocausts and tubulations originate and what was their purpose if they did not serve for heating? The chief explanatory reason for the former fact I would seek less in the influence of Vitruvius and the falsified picture from the Titus thermæ, as Krell does, but rather in the philological archæology which frequently places book knowledge above common sense and which never allowed the technical man, especially the independent practical investigator furnishing actual and accurate results to be heard, calling him an "amateur," but considering itself alone competent to pass judgment in all branches. The real purpose of the subterranean spaces and the hollow walls was to dry the living rooms, and in the case of baths at the same time the possibility of a quick and hygienic cleaning of the bath tank and a strict control, since leaks could be readily located and attended to from the cellaring below.

These theories were worked out by Krell especially from the remains of the thermæ of the Pompeian Forum and the Stabian thermæ. The results gained he applies in a fertile manner to the German remains (as Saalburg, villa near the Saalburg, Basilica, St. Barbara and the Imperial Palace at Trier, Badenweiler, Eining). But when Krell asserts that the practical results would only benefit classical archæology, he modestly underestimates his own services. The results of Krell's work, especially what he says regarding charcoal pan heating, have to be assimilated by every art historian for investigations in former or later periods.

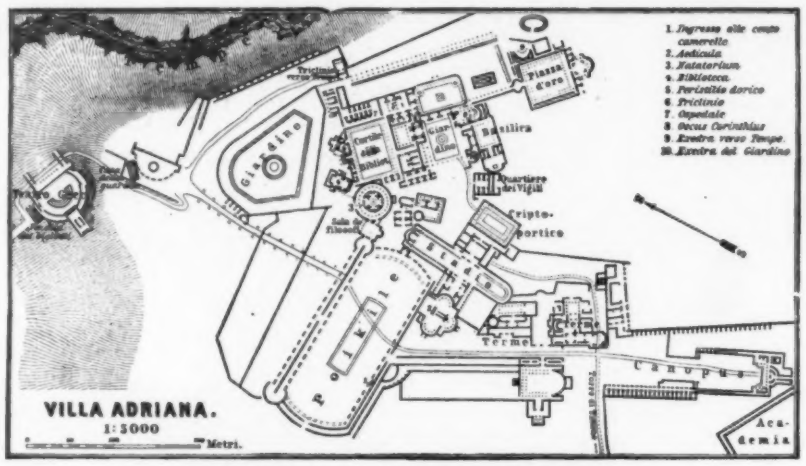
I will point out some incentives. Observe the constantly recurring accumulations of the wall recesses in the frigidaria (cold water bath rooms) of the Stabian and the Forum thermæ at Pompeii and the thermæ at Badenweiler. From the accumulation of recesses for charcoal pan heating one may, inversely, recognize a frigidarium, since, necessarily, the bath room had to be more temperate than in the tepid and warm baths. On the other hand, the recesses occurring everywhere in mediæval abbeys, particularly those of the architecturally efficient Cistercians, the use of which niches has remained unknown, may very plausibly be explained to be devices for heating by means of charcoal pans.

As a typical example I may cite the very peculiar choir niches of the abbey church at Heiligenkreuz in the Wienerwald (founded in 1135, Choir XIV. sæc.)

Alongside of all the side altars surrounding the free main altar are two niches close together; one served as the ritual "Credentia," i. e., as place for the mass wine and water, the other has a bowl cut out with the chisel (diameter about 20 centimeters) for the reception of the charcoal. There are likewise two niches in the dormitory (sleeping room of the monks). For locating the dormitories and calefactories of the cloisters the results of Krell's researches may be used with great advantage. The "Conchæ" of the Romanic churches of Germany, the "ritualia," "definitiones," "nomastica," etc., of the old orders, veritable treasure mines of early mediæval architecture, could be successfully explored and would thus indirectly furnish new material to the history of civilization.

Outside the scientific merit of the book, as pointed out, it possesses, especially for Germany, a high social value by showing that the modern technician will gain for himself an honorable place in the field of historic disciplines thus successfully entered by Krell, and will also compel recognition on the part of those who have heretofore stubbornly denied it to him.—Translated for the Scientific American Supplement from the German of Dr. Lanz von Liebenfels, in Prometheus.

* Thus are called the antique heating devices whose gases, as was heretofore supposed, were conducted under the floors resting on columns, thus heating the rooms, or in the case of baths, the water over the floors.



PLAN OF HADRIAN'S VILLA NEAR TIVOLI.

THUMB RING LORE.

The custom of wearing rings upon the thumb prevailed in England until the close of the eighteenth century, and is of very ancient origin. There is a mummy case in the British Museum which represents an Egyptian lady wearing rings upon the thumbs of both her hands. The Romans were greatly addicted to this practice, and as many of their thumb rings were most cumbersome and inconvenient, the patricians varied their rings with the season, terming them "Summer" or "Winter" rings, as the case might be. During his visit to Rome, Addison saw some of these old rings, and comments thus upon them: "So very thick about, and with such large stones in them, that 'tis no wonder a fop should reckon them a little cumbersome in the summer season of so hot a climate." The Emperor Trajan possessed a "winter thumb ring" which measured some three and a half inches in width and bore a bust in high relief of his consort, Plotina. English thumb rings do not appear to have been less massive. During the latter part of the Middle Ages they formed part of the necessary adornment of a bishop when he was arrayed in full pontificals.

Thomas à Becket possessed a thumb ring set with a valuable ruby, which was about the size of a hen's egg. This ring was a gift from Louis VII. of France. At the Reformation, Bluff King Hal seized the Archbishop's ring from his despoiled shrine, and took it for his own personal adornment, thus bringing thumb rings back into fashion for a while. They had long been abandoned by the upper classes and had gradually come to be considered as indicative of the burgess class. Thumb rings were often set with the tooth of some animal as an amulet. A wolf's tooth was supposed to act as a charm against assault, while a badger's tooth brought wealth and general good luck. The crapandine, or toadstone, was also used in this way, as it was supposed to possess various mystic virtues, one of which being the power of warning its wearer of the presence of poison in his food or drink by changing its color. The mystic word "Anamyaptus" was often engraved upon a thumb ring as a charm against epilepsy or cramp. This was in accordance with an old superstition, which gives this word as a cure "for the falling sickness." Another favorite preventive of epilepsy was a silver thumb ring engraved in Gothic characters with the names of Jasper, Melchior and Balthazar, the three Wise Men

INTERIOR OF LIBRARY, HADRIAN'S VILLA.

from the East. In "The Squire's Tale" Chaucer mentions a magical thumb ring worn by Canace, the daughter of "Cambuscan Bold," which gave her a complete knowledge of the medicinal values of herbs and enabled her to converse with birds in their own language. Wedding rings were formerly worn upon the thumb, but did not always stay there. In the ancient ritual of marriage the bridegroom was directed to place the ring upon the thumb at the words "With all my worldly goods I thee endow," moving it to the other fingers in succession.

THE MOROS AND THEIR COUNTRY.

By STEPHEN BONSAL.

I VISITED Malabang, which is pronounced Malávan, and means made or reclaimed land, early last December. We had timed our movements, or rather those of the United States naval tug upon which we traveled, so as to arrive at this mart of Moro trade on market day. We arrived on time, steaming across the bay from Cottabato, and anchored off the shelving beach; but the Moros did not appear in the numbers we had been led to expect. We were informed by the officers serving at the post that the situation in the last few days had undergone a change for the worse. Far from any realization of the sanguine expectations so often expressed that Malabang would become at an early day a busy center of trade, the small permanent population of the place, Moros, Chinese, Filipinos and "mixed," were moving away. They made no secret of the fact, as they went, that they moved because Malabang was destined in a very few days to become the scene of, as a Chinese merchant put it, "large trouble."

Malabang is not much to look at, but we thought it worth a visit because it is the only place where an opportunity might present itself of touching elbows and exchanging snuff with the mighty Moro chiefs of the Lake Lanao League, against whom the Spaniards waged for so many years a war of subjugation without any very conspicuous success in the end. I found a good deal of guessing going the rounds of the Mindanao garrisons as to the strength of this League, and as to the sentiments with which its members are animated. Unfortunately, it was all guessing of the purest description, and guessing it will remain until our officials and troops buckle down and learn Moro, and are made to dispense with the imaginative half-breed interpreters, that bane of the situation in the Philippines.

What we actually know of the Lake Moros may be condensed into a single sentence: that they have from the beginning been averse to coming into close contact with us, that for three years they have been successful in maintaining their policy of non-intercourse, and that now they seem determined upon war, for which, doubtless, they have been preparing ever since our landing on the island. How the trouble which has since developed into the "little war" upon which we find ourselves engaged originated, it would be difficult to say. These, however, are some of the circumstances which came under my observation while on the spot, and which have undoubtedly had much to do with creating the present state of affairs.

The civil authorities, the moment the Philippine Commission succeeded to the supreme power throughout the archipelago, which was on July 4, 1901, began with laudable zeal to protect the forests and the rich plant-life of the island from the thoughtless, short-sighted exploitation they are exposed to at the hands of the ignorant Moros, who are more often than not urged on to commit their depredations by the rapacious Chinese merchants in whose debt they live, with but few exceptions, from the cradle to the grave. The best timber was being destroyed in the most reckless manner, and the rubber plants were being cut down in a way that was still more wasteful. In order to secure the precious rubber fluid to the last drop, instead of tapping the trunk, the whole tree was cut down and destroyed to obtain the harvest of one year, and this not only meant the destruction of all the rubber trees in a very few years, as no young plantations were set out, but the rubber obtained in this way was of a very poor, "dead" quality.

To stem these abuses a derelict Spaniard living at Malabang was appointed forester and superintendent of the rubber supply. Under the Forestry Bureau regulations, he was authorized to issue timber certificates and to collect a tax on all the rubber brought into the market. This tax, as we had seen very strikingly illustrated in Cottabato, was prohibitive on timber, some logs being taxed three dollars Mexican each, when that was all the cutter could expect to receive for them when, after infinite labor, he had succeeded in floating them down the river to the market.

Upon the dead rubber, extracted in the manner I have described, a tax designed to be prohibitive was imposed, while the rubber obtained by tapping the trees was admitted to the freedom of the market after paying a merely nominal octroi. Then the troubles began, which soon culminated in the murder of Señor Gonzalez, the tax collector. Naturally, the Moros charged him with all manner of dishonest dealings. He was a trader, and had been permitted to trade after receiving his official appointment. The Moros accused him of driving his competitors out of the field by excessive taxation, and admitting all the purchases of his own firm free of impost. The facts are that the imposition of these taxes was premature, and that in some respects the scale upon which they were adjusted displayed complete ignorance of the local conditions. And in the discussion of these tariff questions, unhappily, Señor Gonzalez was killed.

It was known pretty generally who his murderers were, and shortly before our arrival Capt. Wrenn, commanding the post at Malabang, had sent a formal demand upon their datu or over-lord to deliver up the men for trial, and no answer had been received up to the day we left—no answer, that is, except the almost complete boycott of the market, which, most unfortunately for us, was inaugurated on the day of our arrival. Instead of the six or seven hundred Moros gayly decked out in their many-colored kerchiefs and sarongs; instead of the sovereign sultans in their many-oared barges or their red and black sailed *praus*, preceded by their private and personal executioners and followed by their suppliant courtiers and the gangs of slaves burdened with the products of the Moro country, there only presented themselves to our disappointed gaze some thirty or forty shabby individuals, who had come, it is true, from Lake Lanao, but had brought with them nothing to sell but a few sarongs. All day they sat on their mats chewing buyo, or betel-nut, and spying out the land. Toward evening they rolled up their mats and disappeared, some in their swiftly-moving craft, others in the jungle that closed behind them; and Malabang, the mart of the Moro confederation, had been as quiet as the grave but for our lamentations.

The Chinese and the Filipino traders, more practiced than we in interpreting the motives and intentions of this peculiarly close-mouthed people, all agreed that their conduct admitted of but one explanation. It meant war, they said in their different dialects, and they packed up their goods and huddled together under the guns of the fort awaiting with ill-concealed impatience transportation to Zamboanga. By the soldiers the news that there was to be war was received with evident cheerfulness. It had been so dull slouching around upon this lonely beach, month in and month out, that the pleasure with which the war news was received was natural, if reprehensible. Our position here was and is an important one, for Malabang is our most advanced post in the territory of the Lanao confederation, and will have to serve as our base in all operations against the Moro forces concentrated around the sacred lake which they have sworn to shield from the pollution of the Christian presence. The barracks, or main *cuartel*, is a large granite building with walls of medieval thickness. As the inscription over the drawbridge (it is also defended by a moat) proclaims, it was constructed early in the last century by Gen. Corcuera, one of the Spanish conquistadores, who left a deeper impression than all the rest upon the Moro country. The moat is filled with crystal water of wonderful transparency and, it is said, medicinal virtues, which flow from seven springs, all within a few feet of one another, and all bubbling up within the barrack yard. This main fort is about a mile from the beach, where the market is situated. The line of communication between the two, running through a swampy jungle, is fortified by two stone martellos, or loopholed watch-towers, also the work of Gen. Corcuera. These three defensive points are connected by a deep trench, along which the soldiers can pass from one point to another, as the emergency requires, without being exposed to the enemy's fire.

The last glimpse that we caught of Malabang was prophetic of war. All the soldiers and all the available coolies were out cutting down the rank jungle-grass from around the fortifications, which might so well shelter the advance of an enemy, and the officers were engaged in ascertaining the exact range of the prominent points on the landscape over which an attacking force would have to pass.

But for three months the Moros did not return to Malabang, either as traders or as warriors. Indeed, nothing happened to disturb the monotony of life on the Mindanao coast until early in March, when, the vigilance of our men, which apparently can never be maintained for long, having relaxed, the Moros, with peaceful promises, decoyed two soldiers of the Malabang garrison into an ambuscade. As a result one was killed and the other seriously wounded, and, as on previous occasions, the datus refused to deliver up the guilty men, or to punish them according to their own laws.

In view of these facts, General Chaffee at last decided to act. It was apparent to me while in Mindanao that no effort consistent with self-respect was being spared to postpone the inevitable Moro campaign, so I am inclined to think that the necessity for action must be imperative. There is an apologetic strain running throughout the despatch in which General Chaffee announces the mobilization of the organizations which, under the command of Colonel Baldwin, have been selected to advance into the Moro country, and I, for one, am not inclined to dispute General Chaffee's decision, made upon the spot and with all the facts before him. No one acquainted with the conditions in the islands can approve the proposition which is heard in some quarters—to leave the Moros severely alone, and confine our attention for the present to the Tagals and the Visayans. There is no alternative between maintaining our authority or allowing it to fall to the ground. We must bear the white man's burden or we must leave it.

Now that the inevitable moment has come (I trust that it shall also prove an opportune moment), it is most desirable that the campaign should be pushed with energy to a decisive result. For this, many more than the eighteen hundred men that have been placed at Colonel Baldwin's disposal will be required,* and he should have them all at once and not in driblets. It would be characteristic of the Moro to fight eighteen hundred men with stubborn tenacity, while when confronted by four thousand they would doubtless lay down their arms.

The army in the Philippines has taken many chances, penetrated into totally unknown provinces, and gone against forces as to whose strength they were totally ignorant any number of times, and hitherto our tactics, which General Wheaton epitomized with his "Don't stop to fire, but just run 'em down," have always prevailed. It is certain, however, that in no previous campaign of the Philippine war have the elements of uncertainty been so many or the presumptive strength of the enemy so great. In the march from Malabang to the Lake we are entering upon a totally unknown country. Here we have not even the unreliable traditions of our Spanish predecessors to depend upon, the Spaniards having apparently always made their advances into the Lake region from the north by the way of Illigan Bay and the river of that name. As to the numbers of the confederation, how many rifles they can put in the field, whether they are well or ill supplied with ammunition, these are facts which Colonel Baldwin may ascertain within the next few weeks, but it is certain he hasn't got them in his possession now. We have every reason to believe that the Moros of this League are stubborn and tenacious fighters, and there is not the slightest doubt that on several occasions within the last ten years they defeated large forces of Spaniards sent against them. Whatever superiority we possess over the Spaniard in the better *morale* and finer physique of our men is, in my opinion, offset by the knowledge of the language and of the country which the Spaniards had acquired by the exertions of officers preliminary to the war or by the recitals of the Jesuit missionaries, some of whom at various times had penetrated in disguise to the Lake of Lanao, the very Zemzem of Mindanao Mohammedanism. None of our officers speak Moro, and the missionary narratives are not at the disposal of our soldiers.

The only information we have as to the route to the Lake from Malabang, on the south coast, where Colonel Baldwin is gathering his forces, was acquired by the mad prank, as it was called then, of Captain Hagadorn, an infantry officer, who, while stationed somewhere on the coast of Ilana Bay, took the trouble to learn a little Malay and ingratiate himself with the datus. With one of these he got upon such a friendly footing that, after much coaxing on the part of the American officer, an invitation was forthcoming to visit the floating forts on Lake Lanao. Accompanied only by a sergeant and some natives, without having, I believe, secured the countenance of his brigade commander for the venturesome trip, Captain Hagadorn started out from the Malabang fort by the east-northeast trail one day last spring, and on the evening of the second day the broad, tranquil surface of the Lake, studded with floating houses and forts built on piles, opened out before him.

Shortly after leaving the coast, it is evident from his report, the trail runs through a country cut by ravines; then it passes through a jungle about ten miles in extent, through which he states there is no other pass but the one provided by this narrow trail, never more than six feet broad. Twenty-four miles out from Malabang and five or six miles away from the inland lake, the trail emerges from the dark forest jungle into an open, rolling, grass-covered country which extends down to the Lake, which, owing to the nature of the ground, you do not see until quite close upon it. This open country shows signs of primitive cultivation. There are many small coffee plantations, shaded with bamboo-trees; also fields of rice and camotes. There are no villages until you reach the Lake, but the whole country, once the forest is left behind, is dotted with houses, and every few hundred yards there are clumps of bamboo, surrounded by trenches and vine entanglements which the Moros call cottas or forts. In many of these little forts Captain Hagadorn saw rows upon rows of *lantacas*, or the old brass cannon which in former days the Moros carried upon the decks of their piratical praus, and in some of them small field-pieces which appeared to be more modern and decidedly more effective. But the circumstances of his visit were such as to prevent a close inspection. The houses on land that he saw were built of thick bamboo logs flattened out, with roofs of cogan grass, and rafters held in position with bejuco vines. While Captain Hagadorn spent only a few hours at the Lake, and they must have been fully taken up with thoughts of his personal safety, which, as was apparent from the moment of his arrival there, was in great jeopardy, he does not hesitate to say that, should the conquest of the confederation ever have to be undertaken, it could in his judgment be accomplished with a force composed of a brigade of infantry, a troop of cavalry, and a battery of mountain guns, or about twice the number of men now engaged in the campaign.

So far the official report of the adventurous captain. The legend that lurks about the fort at Malabang is full of interesting details which, in view of the circumstances under which his journey was undertaken, Captain Hagadorn doubtless thought best to omit from his official report. According to the legend, the datu who guided him to the Lake, and at whose house he was to pass the night, was received by the other chiefs with marked signs of displeasure when he appeared upon the scene with a hated paleface. The datu, evidently embarrassed, took Hagadorn immediately to his house, where they supped in silence. Shortly before midnight four chiefs rowed up to the house on the bank of the Lake where Hagadorn and his host, very ill at ease, were trying to get to sleep, and an angry conversation took place. The hospitable datu was informed that his conduct had been the subject of closest scrutiny by the general council held that evening, and that the conclusion reached, which they were authorized to announce to him, was this: the only way he could purge himself of the sin against custom and Koranic law in bringing a Christian dog to the sacred lake was to bind the infidel who had evidently bewitched him hand and foot and turn him over to the tender mercies of the League. For a long time the datu fought manfully for the life of his guest friend (and to Hagadorn, who listened, enlightened by his knowledge of Moro, it must have seemed still longer), but all to no purpose. At last the datu threw over his friend, but announced that he would defend his house with his men and his slaves against any invasion. If the members of the League caught the white man trespassing on their territory they could kill him and welcome, but as long as he was under his roof-tree he would defend him. The committee went away apparently satisfied with this decision, which only meant a few hours' postponement of their murderous purpose. But Hagadorn and the sergeant, without saying anything further to their host, whom they had already embarrassed and inconvenienced not a little, slipped out of the datu's house soon after midnight and were half-way along the dark trail to Malabang before the day broke.

If it had been the wish of the Moros to avoid a conflict with our forces, nothing could have been easier than to hand out the red-handed assassins for trial. This and other evidence tends to show that the Lake Moros deliberately provoked the conflict, and it is certain that should we fail to secure justice now our authority and prestige would greatly suffer. The choice of our line of advance from the south is doubt-

* It may be noted that this article was written just before cable despatches from the Philippines announced that the Moro chiefs were showing a disposition to enter into negotiations for peace. Whether they are sincere or not remains to be seen.—The Editors.

less inspired by a desire to avoid friction with the datus of the League who live upon the northern shores of Lake Lanao and along the river Illigan, which, so far as known, is the only outlet of the great lake. These datus bore the brunt of the five or six campaigns with the Spaniards which began in 1890 and were yet in progress when Dewey sailed into Manila Bay. After many setbacks and several bloody defeats the Spaniards had reached a position where they believed the complete subjugation of the Moros would prove an easy matter. A column supported by a mosquito fleet sailing up the Illigan River had reached Lake Lanao, and two little gunboats which had been brought up in pieces from the sea were being put together when the news of Dewey's victory was received. The Spaniards immediately abandoned their advanced position, sinking their gunboats in the lake off Taraca.—The Outlook.

[Continued from Supplement No. 1395, page 22362.]

A REVIEW OF THE EXISTING METHODS OF CULTIVATING ANAEROBIC BACTERIA.*

By Otto F. Hunziker.

ABSORPTION OF ATMOSPHERIC OXYGEN.

To this category belong all those methods in which advantage is taken of the oxygen-absorbing power of some chemical agents. The adoption of this principle for the purpose of bringing about anaerobic conditions

Fig. 30.

is of more recent date than that of exhaustion and of replacement by inert gases.

In 1878 Gunning used a mixture of a ferro salt with an excess of sodium hydroxide. He also recommended a solution of glucose containing indigo carmine and sodium hydroxid.

In 1880 Nenki found that anaerobic bacteria grow well in an atmosphere from which the oxygen has been absorbed by an alkaline solution of pyrogallic acid. Practical application of this principle, however, was not made until 1888, when Buchner invented the method which now carries his name.

Buchner's Method.—Use two test tubes of different sizes (see Fig. 30), drop into the large tube a small wire support on which the small tube is subsequently placed. The small test tube contains the inoculated medium and is closed with a loose cotton plug. Put into the large test tube one gramme of dry pyrogallic acid and then ten cubic centimeters of a one-tenth solution of potassium hydroxid (1 part liquor kali caust. to 10 parts of water). Then quickly lower the small culture tube and close the latter hermetically with a new, elastic, well-fitting, paraffined rubber stopper. Shake well. Buchner observed that the above-stated amount of pyrogallic acid and potassium hydroxid will completely absorb the oxygen in a tube with a cubic content of 100 cubic centimeters in 24 hours at incubator temperature. At lower temperature, as, for instance, in the refrigerator, the absorption of oxygen is much slower. Frequent shaking hastens the absorption.

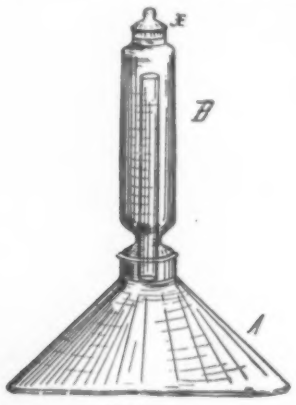


Fig. 31.

For plate cultures Buchner incloses the plates filled with the inoculated medium under a hermetically sealed bell jar and uses larger amounts of pyrogallic acid and potassium hydroxid.

Babes and Puscarin in 1890 modified Buchner's method by putting the inoculated culture tubes into a Fresenius desiccator containing a large amount of pyrogallic acid and potassium hydroxid. After closing the desiccator hermetically with a vaselined ground glass plate the apparatus is put into the incubator. This method enables the experimenter to cultivate numerous tube cultures simultaneously and under identical conditions. The authors obtained the best results when they used media containing 2 per cent glucose.

Blucher (1890) recommends the following method for plate cultures:

Put a petri dish 6 centimeters in diameter, minus cover, into a glass saucer 10 centimeters in diameter and 4 centimeters high. The upper edge of the saucer is ground convexly and it fits exactly into a cover with a concave rim. Into the outer saucer pyrogallic acid and potassium hydroxid are placed and the cover, the concave panel of which has been well vaselinated, is inverted over the saucer. The decrease of pressure within, due to the absorption of the oxygen in the apparatus, causes the over-pressure from without to force the cover tightly over the saucer, forming a hermetical seal. In order to reopen the apparatus the cover must be turned before it can be taken off.

Trambusti's Method.—The apparatus used by this investigator is illustrated in Fig. 31. It consists of two parts: A cone-shaped flask, *A*, containing the medium, and a cylinder, *B*, which is screwed into *A* by means of a fine thread. In the interior of *B* there is a small tube which opens into *A*.

Method.—Pour the inoculated medium, gelatin or agar, into flask, *A*, and distribute it over the surface of the bottom uniformly, the same as in case of a petri dish. Screw *B* into *A*, remove the stopper and fill *B* with an alkaline solution of pyrogallol (2 grammes

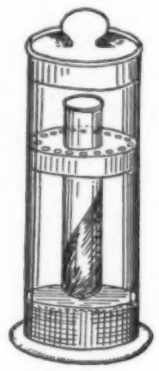


Fig. 32.

of dry pyrogallic acid plus 15 cubic centimeters of 10 per cent solution of KOH), care being taken that the reagent does not enter the small tube. Replace the stopper which has previously been covered with paraffine or vaseline and remove the apparatus to the incubator.

Arens in 1894 used a common small desiccator with a ground glass cover for anaerobic plate cultures.

Method.—Fill the desiccator partly with quartz sand, to this add an optional amount of dry pyrogallic acid, leaving just room for one or two small petri dishes. Use deep layer of agar in the plates. Before putting the plates into the apparatus pour a considerable amount of a 10 per cent solution of caustic potash all over the surface of the sand and acid. Then place the petri dish, minus cover, upon the sand and close the desiccator with a well-vaselined ground glass cover by rotary motion.

Lubinsky in 1894 modified Buchner's method for tube cultures. Instead of putting the culture tube into a large test tube, Lubinsky placed it in a glass cylinder (Fig. 32) 12 to 15 centimeters high and 3 to 4 centimeters in diameter. Into this cylinder he pours the alkaline solution of pyrogallic acid; then he pushes a snugly-fitting, manifold perforated cork about halfway down into the cylinder. In the center of the cork there is a large perforation in which the culture tube is inserted. The cylinder is closed with a glass stopper of ground glass and the edges are sealed with paraffin. When sealed he shakes the apparatus vigorously for two to three minutes to hasten the process of absorption.

Novy recommended his apparatus (Fig. 24) designed for cultivating anaerobes in a hydrogen atmosphere, also for the pyrogallic acid method.

Ucke (1898) manipulated Novy's apparatus (Fig. 24) as follows: Put 10 grammes of dry pyrogallic acid into a small beaker, float this beaker in a larger one (120 cubic centimeters capacity) containing 50 cubic centimeters of a 20 per cent solution of potassium hydroxid and stand the two beakers in the apparatus, so that the glass tube reaching from the glass stopper nearly to the bottom extends into the small beaker. At the last moment, when the apparatus is ready to be put into the incubator, introduce 50 cubic centimeters of water through the long glass tube and turn the glass stopper 90 degrees. This causes the small beaker to sink and the solution of potasium hydroxid mixes with the pyrogallol. By this manipulation the pyrogallic acid does not get access to the alkali until the apparatus is sealed up, hence it is a means of economizing the oxygen absorbing power of the pyrogallol.

Wright (1901) recommends the following modification: Into a medium-sized test tube (see Fig. 33) containing the inoculated culture medium, push a sterile cotton plug well down. By means of a pipette pour ½ cubic centimeter of a saturated solution of pyrogallol and 1 cubic centimeter of a 50 per cent solution of sodium hydroxid upon the cotton plug. Seal the tube with a well-fitting rubber stopper with as little delay as possible. The quantity of the reagent added is so small that there is no danger of its running down along the side of the tube into the culture medium. According to Wright this method can be used successfully for all kinds of flasks and tubes. He lays stress on the fact that the nutrient medium should be freshly boiled and of alkaline reaction.

Slupski (1901) uses the following modification for plate cultures: His apparatus (Fig. 34) consists of a bell jar 15 centimeters in diameter and 5 centimeters high, ending at the bottom in a ground glass rim 1½ centimeters in width. The bell jar is placed in a glass dish about 10 centimeters high. On the bottom

Fig. 33.

of this glass dish rests a double plate. The outer plate, *b*, contains water and the inner, *a*, is designed for pyrogallol. Over the double plate rests a tripod which supports the open petri dish.

Method.—Pour the inoculated culture medium into the open petri dish. Fill plate *b* with water and heap plate *a* with dry pyrogallic acid (25 grammes). To this add 50 cubic centimeters of warm distilled water. Replace tripod. Throw two pieces of KOH (14 grammes) into the pyrogallol. Quickly put a blotter and black paper on top of the tripod, upon which place the open petri dish, invert bell jar, *X*, into glass dish, *Y*, and seal with a thin layer of paraffin. Then pour hot paraffin 3 to 4 centimeters deep into dish, *Y*, and when cooled and congealed pour some liquid paraffin on top. Place the apparatus for about 50 hours in the refrigerator at a temperature of 5 to 6 deg. C. in order to prevent any growth while the absorption of oxygen is still in process. Then put it in the incubator.

Hammerl (1901) uses a mat of heavy cardboard, felt, or cellulose which he saturates with a concentrated solution of pyrogallic acid. This absorbing material he fits into the cover of a deep petri dish.

Method.—Weigh 4 to 5 grammes of dry pyrogallic acid into a small beaker, add a 50 per cent solution of potassium hydroxid, drop by drop, and shake until the pyrogallol is perfectly wet. In a few minutés it will be dissolved. The less potassium hydroxid used the greater is the absorbing power of the solution. Drop the solution of alkaline pyrogallol upon the mat

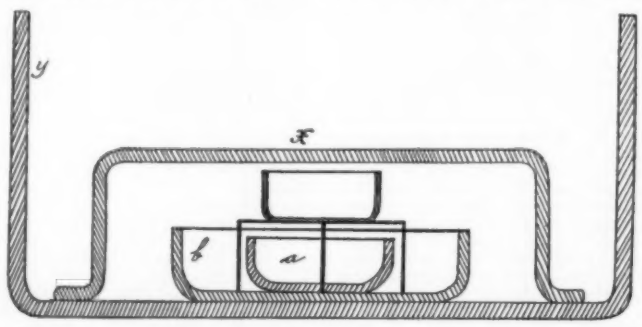


Fig. 34.

of cardboard, felt or cellulose. Do not saturate the absorbing material completely, otherwise some of the reagent might run down into the medium. Invert the cover containing the absorbed reagent over the culture plate, which has previously been filled with the inoculated medium. Seal the space between the rim of the cover and that of the plate with a mixture of white wax (12 parts) and beef tallow (100 parts) and finally cover the seal with a firm and well-fitting rubber band.

For single tube cultures Smith* uses the following

* Journal of Applied Microscopy and Laboratory Methods.

* The method of Dr. Erwin F. Smith, Department of Agriculture, Bureau of Plant Industry, Washington, D. C., has not as yet been published.

device: Into one end of a large U tube insert a small test tube containing the inoculated culture medium. Invert the other end over a small slender flask or vial containing a strongly alkaline solution of pyrogallol and standing the ends of the tube in a dish containing oil.

The writer modifies Smith's method as shown in Fig. 35. Into one end of a large U tube place about 3 grammes of dry pyrogallic acid and 3 grammes of sodium hydrate. Close this end with a rubber stopper and pour about 15 cubic centimeters of water into the other end, *b*, holding the U tube so that the water all escapes into the branch, *a*, containing the reagents. Now insert in the second branch, *b*, a small test tube, *c*, containing the inoculated medium and a loose cotton plug. Close this end of the U tube with a rubber stopper and stand the U tube in a beaker, *d*, containing mercury or gycerin. Good results were obtained by this method.

Nikirforoff introduced a method by which anaerobes can be cultivated in a hanging drop.

Method.—Use a slide which carries a ground glass ring, just as for making an ordinary hanging drop preparation. Cover the ground edge of the ring which is used for the support of the cover glass with vaseline. Place the cover glass with the hanging drop on the ring, so that one side of the ring is not covered. Insert here a small drop of pyrogallic acid. Move the cover glass into its proper place, that is, so that it covers the ring completely. The drop of pyrogallol now spreads over the whole periphery between the cover glass and ring. Now carefully move the cover glass in the opposite direction and put a drop of potassium hydroxid upon the thus uncovered part of the ring. Replace the cover glass and make it fast. The two drops will mix and the absorption of oxygen takes place. Instead of applying the alkaline pyrogallol on the surface of the ring, it may be put on the bottom of the object carrier in the center of the ring. Later, Nikirforoff and Braatz devised special object carriers in which the hanging drop may be examined in a hydrogen atmosphere.

Salomonson (1889) suggests the use of aerobic bacteria as the agents for the absorption of oxygen. He uses two test tubes (Fig. 36). The smaller inner tube, *a*, contains the culture medium inoculated with the anaerobic species. The larger outer tube, *b*, with constricted neck and cotton plug holds a bouillon culture of one or more strictly aerobic species. As

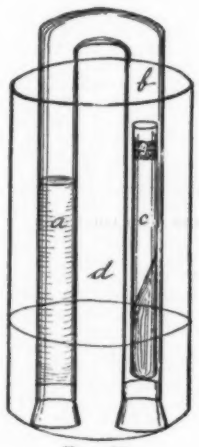


FIG. 35.

soon as both tubes are inoculated with their respective organisms the outer tube, *b*, is sealed at *c*.

Besides the various apparatus described in this category, most of the apparatus for plate cultures referred to under Classes I and II may also be used for the pyrogallol method.

REDUCTION OF OXYGEN.

In order to simplify apparatus and manipulation used for cultivating anaerobic bacteria, and to be able to make cultures of anaerobes in the presence of air, attempts were made to reduce the oxygen in the medium. Various agents have been used to accomplish this end.

A. Mixed Cultures.

One of the simplest though not altogether satisfactory ways to cultivate anaerobes under aerobic conditions is that of making mixed cultures, i. e., the culture medium containing the anaerobic species sought for is inoculated with one or more strictly aerobic species. While many investigators have used this method successfully, there seems to exist some controversy regarding the specific role which the aerobes play in preparing favorable conditions for the anaerobes in mixed cultures. Pasteur holds that the aerobic bacteria are capable of using up all the oxygen present in the culture medium, and that in this way they make it possible for the anaerobes to thrive in mixed cultures. Kedrowski attributes this fact to another phenomenon. He holds that the conditions favorable for anaerobic development in mixed cultures are not due to the assimilation of the oxygen present in the nutrient medium by the aerobic species, but that the latter produce substances which form a suitable medium for the anaerobes to grow in.

Roux recommends the following method for mixed cultures: Boil a convenient quantity of nutrient agar in a cotton-plugged test tube and cool rapidly in cold water. Immediately after the agar is solidified inoculate it with the anaerobic organism by means of a glass needle, then pour a small amount of melted but not too hot nutrient gelatin into the tube. When this is congealed pour a few drops of a bouillon culture of *Bacillus subtilis* upon the surface of the gelatin. Seal the tube in the flame and place it in the incubator. *Bacillus subtilis* grows very rapidly upon the surface, forming a tough membrane and using up the oxygen in the tube. In order to obtain material for anaerobic subcultures, the bottom of the test tube is broken, avoiding the mixing for the two cultures.

Penzo (1891) used a similar method. He cultivated the bacillus of malignant œdema successfully under aerobic conditions in agar and gelatin containing cultures of *Bacillus prodigiosus* or *Proteus vulgaris*.

Scholtz (1898) observed that anaerobes grow much more vigorously in a medium containing a vigorous culture of an aerobic species.

While it is evident that mixed cultures are a simple and generally successful means for obtaining vigorous anaerobic growth, it is equally obvious that this method is unsatisfactory where pure cultures of anaerobic bacteria must be obtained. Therefore, the use of mixed cultures can serve only as an indirect means in studying anaerobic bacteria.

B. Chemical Reducing Agents.

Glucose.—Librius, in 1886, observed that the addition of glucose to nutrient bouillon, gelatin or agar exerted a favorable influence on the development of anaerobic species. This action has been explained by the fact that glucose in an alkaline solution possesses an oxygen-reducing power.

Novy (1893) successfully used and recommends media with the following ingredients for the cultivation of anaerobes:

1. Beef broth containing ½ per cent sodium chloride, 2 per cent peptone and 2 per cent glucose.

2. Beef broth as above plus 2 per cent gelatin.

3. One to 15 per cent nutrient gelatin with the same constituents as under 1.

4. One and a half to 2 per cent agar containing ½ per cent sodium chloride, 2 per cent peptone and 2 per cent glucose.

Hewlett's method: Fill a test tube two-thirds with 2 per cent glucose agar and steam immediately before inoculation to expel any traces of oxygen that may be present in the nutrient medium. When the agar has set, inoculate well into the depth of it. Carefully warm the tube over the flame, melting the superficial layer of agar and filling the puncture made by the inoculation. Now flame the upper portion of the tube to expel the air and slip a well-fitting rubber cap over the hot test tube.

Babes and Puscarin (1890) use high layers of 2 per

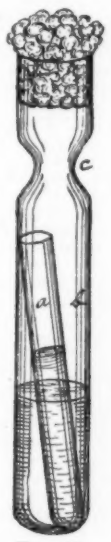


FIG. 36.

cent glucose agar in tubes. After inoculation they expose the tubes to 80 deg. C. for a short time, push the plug down nearly to touch the surface of the medium and then pour liquefied paraffin on top of the plug.

Ucke (1898) recognizes in glucose a two-edged sword, and attributes the frequent failures in the cultivation of the anaerobic bacteria to the use of glucose. Although a more vigorous growth is formed on glucose medium, the spores, if formed at all, are less numerous; degeneration forms are apt to develop, and the virulence of the organism is lessened. He holds that if vigorous growth and spore producing material shall be obtained, media without sugar should be used.

Other reducing agents: Kitasato and Weyl (1890) tested the action of a large number of reducing agents in alkaline media on the development of anaerobic bacteria. Their purpose was to find a substance of a greater reducing power than glucose, and which at the same time would not exert a harmful influence on the bacterial development. They demonstrate that the addition to the culture medium of Pyrocatechin $C_6H_4(OH)_2$, the sodium salt of Amidonaphtol-monosulphonic acid $C_{10}H_5OHNH_2SO_3Na$, sodium indigo sulphonate $C_{16}H_8N_2O_2(SO_3Na)_2$, Sodum formate HCO_2Na, in quantities of 0.1 per cent exerted a favorable influence on the anaerobic growth, while other reducing reagents, such as Hydroxylaminehydrochloride $NH_2(OH)Hcl$, Resorcin $C_6H_4(OH)_2$, Hydroquinone $C_6H_4(OH_2)$, Pyrogallol $C_6H_3(OH)_3$, Acetaldehyde CH_3COH, Benzaldehyde C_6H_5COH, phenylhydrazinehydrochloride $NH_2—NH(C_6H_5HCl)$, etc., either did not affect the culture materially, or exerted a strong poisonous action on the micro-organisms. The authors especially recommend the use of sodium sulphonate (use 0.1 per cent). This agent is valuable, however, as an indicator of the reducing effect of certain bacteria rather than as a reducing agent in itself.

Buchner first recommended litmus to indicate changes of reaction caused by bacteria. Later, Cohen proposed its use as a reduction indicator. This is important, as many bacteria, and especially anaerobic forms, reduce litmus rapidly to a colorless leuco substance, which, upon access of oxygen, colors red or blue according to the reaction changes.

Novy observed that the addition of litmus favors to a certain extent the growth of the micro-organisms, and that it exerts a protecting influence over the anaerobic bacteria. Cultures of the bacilli of tetanus, black leg and malignant œdema retain their vitality even in liquid media exposed to the air for months if they are colored with litmus.

Trenkmann (1898) recommends the addition of a few drops of a 10 per cent solution of sodium sulphide Na_2S to bouillon; take 20 cubic centimeters of nutrient medium and two drops of a 10 per cent solution of Na_2S. The author cultivated the bacillus of black leg successfully in such a medium in the presence of air. He admits, however, that Na_2S gradually decomposes by the action of CO_2 in the atmosphere, forming Na_2CO_3 and H_2S. As soon as this action takes place the atmospheric oxygen re-enters the medium and checks the growth of the anaerobic organisms.

Hammerl (1901) tested the efficiency of Trenkmann's Na_2S, of K_2S and of ammonium sulph-hydrate NH_4SH, as reducing agents. Parallel experiments showed that NH_4SH was much more efficient than either Na_2S or K_2S. In the ammonium sulph-hydrate he believes he has found a substance which, without checking the bacterial development, reduces the oxygen in the nutrient medium and thus prepares ideal conditions for anaerobic cultures. Unfortunately the ordinary NH_4SH as kept in the laboratory is not fit for this purpose. It is necessary that it should be fresh and sterile. To obtain sterile NH_4SH the following procedure is recommended: Fill a glass stoppered bottle of 100 to 150 cubic centimeters capacity completely with sterile water. Replace the glass stopper by a cotton plug and sterilize the apparatus in the steam sterilizer. After sterilization cool it to room temperature and introduce by means of a sterile glass tube, reaching to the bottom of the bottle, a vigorous current of washed H_2S for about six minutes. The open end of the bottle is loosely plugged with sterile cotton. Now draw from the sulphureted water accurately measured portions of 10 cubic centimeters into each of 6 to 8 sterile test tubes; by means of a pipette drop into the first tube two drops, into the second four drops, etc., of a 1 per cent solution of ammonium chloride NH_4Cl. After vigorous shaking add three drops of a concentrated solution of methylene blue to each tube. The latter operation is done most easily by pouring the 10 cubic centimeters into a tube containing the three drops of methylene blue. Mark the time required for complete decolorization. Generally the optimum amount of ammonium salt lies between four to eight drops and the minimum time for decolorization from one-quarter to one minute. Upon finding the optimum amount of NH_4Cl a corresponding number of drops of a 1 per cent solution of NH_4Cl is added to the sulphureted water in the bottle. Then add to ten parts of the nutrient medium one part of the thus prepared solution. If about three drops of concentrated methylene blue are added to this medium the latter decolorizes rapidly and completely in two to three minutes.

From the above review of the various reducing agents and their comparative efficiency as a means for producing conditions favorable for the development of anaerobic bacteria in the presence of air, it may be seen that none of the agents and substances so far in use are entirely satisfactory. If aerobic species are used for this purpose, it is difficult to obtain the anaerobes in pure cultures without the aid of some other method for the cultivation of anaerobic bacteria. If we resort to chemical reducing agents we find that while they may favor anaerobic growth, they may do it at the expense of spore formation, and that they may cause the development of degeneration forms, as in the case of glucose, or the reducing substance may have a poisonous effect on the micro-organisms as in the case of hydroxylaminehydrochloride, or the preparation of the reducing agent in sterile form may be too complicated for practical purposes, as in case of ammonium sulph-hydrate, and finally that, no matter how great the reducing power of any one of these chemical reducing agents may be, they are not able to make harmless the atmospheric oxygen, which reenters the medium when the latter is poured into petri dishes. Generally speaking then, in order to use reducing agents successfully, they should be used in connection with some other method for cultivating anaerobic bacteria.

(To be continued.)

THE BIOLOGICAL REACTION OF BLOOD.

THE biological reactions of blood have been for some time past studied by Prof. G. H. Nuttall. His results show that if human blood be injected into the rabbit, for example, the serum of the rabbit becomes an "anti serum" for human blood. If it be added to the serum of human blood it precipitates the latter. Moreover, it precipitates human blood and no other, if exception be made of certain species of apes. It is without action on other blood serums. In the same way anti-serums can be made for the blood of horses, pigs, dogs, etc. Mr. Nuttall has lately published the results of new experiments of the sort. He tried anti-human serum on forty-six specimens of the blood of apes and finds that anti-human serum is in a measure anti-ape, also. That is to say, the anti-human serum gives a precipitate with the blood of the anthropoid apes that is not to be distinguished from that obtained from human blood. This indicates a close zoological affinity between the two groups of animals. No precipitate is given with the lemurian group. With chimpanzee blood the reaction is the same as for men.

The anti-horse serum has been tried on 495 specimens of blood. The result has always been negative, except with the blood of horses and asses. A like result follows from anti-serums made from the blood of dogs, cattle and sheep. They act on the blood of dogs, oxen and sheep respectively and on no others. It is noteworthy that the anti-pig serum is exceptionally vigorous in its action and reacts (if sufficient time is given) with the blood of apes, bears, men, dogs, rats, antelopes, etc., and also with that of bats, of eight of the marsupials, etc.

The conclusion would at first appear to be that the pig has affinities with the whole series of mammalia. But this is evidently not the conclusion that should be

drawn, but rather that beside the specific anti-serum there is a generalized anti-serum, the anti-mammalian. Every especial vigorous specific anti-serum will give not only a specific, but a general, anti-mammalian reaction. This fact, with our present knowledge, tends to weaken the value of the tests by Nuttall's process in medical jurisprudence and in biology. No anti-serum of a mammal gives a reaction with non-mammalian blood.

The specific qualities of anti-serums attain their maximum in the case of mammals. Mr. Nuttall has shown that anti-chicken and anti-ostrich serums act more or less on the blood from any species of fowl, though not at all on blood from any creatures except birds. The experiments have been tried on 510 specimens of blood, of which 153 were from birds. Mr. Nuttall has formed an anti-egg serum. It acts especially on the white of the egg of fowls, but very slightly on their blood. But it also acts on the blood of turtles and crocodiles, and apparently on no other specimens of blood. Have we here a confirmation of the theory of kinship between birds and reptiles? The anti-alligator serum has been tried on 500 specimens of blood and reacts only with alligator and turtle blood. Anti-lobster serum tried also on 500 specimens reacts only with the blood of lobsters and crabs and not at all with the blood of non-crustaceans. Anti-frog serum reacts with frog blood, but not at all with the blood of non-batrachians. The research is evidently of high importance and promises to be very fruitful in results.

HISTORY OF COLD AND THE ABSOLUTE ZERO.*

By Prof. James Dewar.

It was Tyndall's good fortune to appear before you at a moment when a fruitful and comprehensive idea was vivifying the whole domain of scientific thought. At the present time no such broad generalization presents itself for discussion, while on the other hand the number of specialized studies has enormously increased. Science is advancing in so broad a front by the efforts of so great an army of workers that it would be idle to attempt within the limits of an address to the most indulgent of audiences anything like a survey of chemistry alone. But I have thought it might be instructive, and perhaps not uninteresting, to trace briefly in broad outline the development of that branch of study with which my own labors have been recently more intimately connected—a study which I trust I am not too partial in thinking is as full of philosophical interest as of experimental difficulty. The nature of heat and cold must have engaged thinking men from the very earliest dawn of speculation upon the external world; but it will suffice for the present purpose if, disregarding ancient philosophers and even medieval alchemists, we take up the subject where it stood after the great revival of learning, and as it was regarded by the father of the inductive method. That this was an especially attractive subject to Bacon is evident from the frequency with which he recurs to it in his different works, always with lamentation over the inadequacy of the means at disposal for obtaining a considerable degree of cold. Thus in the chapter in the Natural History, "Sylva Sylvarum," entitled "Experiments in consort touching the production of cold," he says, "The production of cold is a thing very worthy of the inquisition both for the use and the disclosure of causes. For heat and cold are nature's two hands whereby she chiefly worketh, and heat we have in readiness in respect of the fire, but for cold we must stay till it cometh or seek it in deep caves or high mountains, and when all is done we cannot obtain it in any great degree, for furnaces of fire are far hotter than a summer sun, but vaults and hills are not much colder than a winter's frost." The great Robert Boyle was the first experimentalist who followed up Bacon's suggestions. In 1682 Boyle read a paper to the Royal Society on "New Experiments and Observations Touching Cold, or an Experimental History of Cold," published two years later in a separate work. This is really a most complete history of everything known about cold up to that date, but its great merit is the inclusion of numerous experiments made by Boyle himself on frigorific mixtures, and the general effects of such upon matter. The agency chiefly used by Boyle in the conduct of his experiments was the glaciating mixture of snow or ice and salt. In the course of his experiments he made many important observations. Thus he observed that the salts which did not help the snow or ice to dissolve faster gave no effective freezing. He showed that water in becoming ice expands by about one-ninth of its volume, and bursts gun-barrels. He attempted to counteract the expansion and prevent freezing by completely filling a strong iron ball with water before cooling; anticipating that it might burst the bottle by the stupendous force of expansion, or that if it did not, then the ice produced might under the circumstances be heavier than water. He speculated in an ingenious way on the change of water into ice. Thus he says, "If cold be but a privation of heat through the recess of that ethereal substance which agitated the little eel-like particles of the water and thereby made them compose a fluid body, it may easily be conceived that they should remain rigid in the postures in which the ethereal substance quitted them, and thereby compose an unfluid body like ice; yet how these little eels should by that recess acquire as strong an endeavor outward as if they were so many little springs and expand themselves with so stupendous a force, is that which does not so readily appear." The greatest degree of adventitious cold Boyle was able to produce did not make air exposed to its action lose a full tenth of its own volume, so that, in his own words, the cold does not "weaken the spring by anything near so considerable as one would expect." After making this remarkable observation and commenting upon its unexpected nature, it is strange Boyle did not follow it up. He questions the existence of a body of its own nature supremely cold, by participating in which all other bodies obtain that quality, although the doctrine of a *primum frigidum* had been accepted by many sects of philosophers; for, as he says, "if a body being cold signify no more than its not having its sensible parts so much agitated as those of our sensorium, it suffices that the sun or the fire or some other agent, whatever it were, that agitated more vehemently its parts before, does either now cease to agitate them or agitates them but very remissly, so that till it be determined whether cold be a positive quality or but a privative it will be needless to contend what particular body ought to be esteemed the *primum frigidum*." The whole elaborate investigation cost Boyle immense labor, and he confesses that he "never handled any part of natural philosophy that was so troublesome and full of hardships." He looked upon his results but as a "beginning" in this field of inquiry, and for all the trouble and patience expended he consoled himself with the thought of "men being oftentimes obliged to suffer as much wet and cold and dive as deep to fetch up sponges as to fetch up pearls." After the masterly essay of Boyle, the attention of investigators was chiefly directed to improving thermometrical instruments. The old air thermometer of Galileo being inconvenient to use, the introduction of fluid thermometers greatly aided the inquiry into the action of heat and cold. For a time great difficulty was encountered in selecting proper fixed points on the scales of such instruments, and this stimulated men like Huygens, Newton, Hooke and Amontons to suggest remedies and to conduct experiments. By the beginning of the eighteenth century the freezing-point and the boiling-point of water were agreed upon as fixed points, and the only apparent difficulties to be overcome were the selection of the fluid, accurate calibration of the capillary tube of the thermometer, and a general understanding as to scale divisions. It must be confessed that great confusion and inaccuracy in temperature observations arose from the variety and crudeness of the instruments. This led Amontons in 1702-3 to contribute two papers to the French Academy which reveal great originality in the handling of the subject, and which, strange to say, are not generally known. The first discourse deals with some new properties of the air and the means of accurately ascertaining the temperature in any climate. He regarded heat as due to a movement of the particles of bodies, though he did not in any way specify the nature of the motion involved; and as the general cause of all terrestrial motion, so that in its absence the earth would be without movement in its smallest parts. The new facts he records are observations on the spring or pressure of air brought about by the action of heat. He shows that different masses of air measured at the same initial spring or pressure, when heated to the boiling-point of water, acquire equal increments of spring or pressure, provided the volume of the gas be kept in its initial value. Further, he proves that if the pressure of the gas before heating be doubled or tripled, then the additional spring or pressure resulting from heating to the boiling-point of water is equally doubled or tripled. In other words, the ratio of the total spring of air at two definite and steady temperatures and at constant volume is a constant, independent of the mass or the initial pressure of the air in the thermometer. These results led to the increased perfection of the air thermometer as a standard instrument, Amontons' idea being to express the temperature at any locality in fractions of the degree of heat of boiling water. The great novelty of the instrument is that temperature is defined by the measurement of the length of a column of mercury. In passing, he remarks that we do not know the extreme of heat and cold, but that he has given the results of experiments which establish correspondences for those who wish to consider the subject. In the following year Amontons contributed to the Academy a further paper extending the scope of the inquiry. He there pointed out more explicitly that as the degrees of heat in his thermometer are registered by the height of a column of mercury, which the heat is able to sustain by the spring of the air, it follows that the extreme cold of the thermometer will be that which reduces the air to have no power of spring. This, he says, will be a much greater cold than what we call "very cold," because experiments have shown that if the spring of the air at boiling-point is 73 inches, the degree of heat which remains in the air when brought to the freezing-point of water is still very great, for it can still maintain the spring of 51½ inches. The greatest climatic cold on the scale of units adopted by Amontons is marked 50, and the greatest summer heat 58, the value for boiling water being 73, and the zero being 52 units below the freezing-point. Thus Amontons was the first to recognize that the use of air as a thermometric substance led to the inference of the existence of a zero of temperature, and his scale is nothing else than the absolute one we are now so familiar with. It results from Amontons' experiments that the air would have no spring left if it were cooled below the freezing-point of water to about 2½ times the temperature range which separates the boiling-point and the freezing-point. In other words, if we adopt the usual centennial difference between these two points of temperature as 100 degrees, then the zero of Amontons' air thermometer is *minus* 240 degrees. This is a remarkable approximation to our modern value for the same point of *minus* 273 degrees. It has to be confessed that Amontons' valuable contributions to knowledge met with that fate which has so often for a time overtaken the work of too-advanced discoverers; in other words, it was simply ignored, or in any case not appreciated by the scientific world either of that time or half a century later. It is not till Lambert, in his work on "Pyrometrie" published in 1779, repeated Amontons' experiments and indorsed his results that we find any further reference to the absolute scale or the zero of temperature. Lambert's observations were made with the greatest care and refinement, and resulted in correcting the value of the zero of the air scale to *minus* 270 degrees as compared with Amontons' *minus* 240 degrees. Lambert points out that the degree of temperature which is equal to zero is what one may call absolute cold, and that at this temperature the volume of air would be practically nothing. In other words, the particles of air would fall together and touch each other and become dense like water; and from this it may be inferrred that the gaseous condition is caused by heat. Lambert says that Amontons' discoveries had found few adherents because they were too beautiful and advanced for the time in which he lived.

About this time a remarkable observation was made by Prof. Braun at Moscow, who, during the severe winter of 1759, succeeded in freezing mercury by the use of a mixture of snow and nitric acid. When we remember that mercury was regarded as quite a peculiar substance possessed of the essential quality of fluidity, we can easily understand the universal interest created by the experiment of Braun. This was accentuated by the observations he made on the temperature given by the mercury thermometer, which appeared to record a temperature as low as *minus* 200 degrees C. The experiments were soon repeated by Hutchins at Hudson's Bay, who conducted his work with the aid of suggestions given him by Cavendish and Black. The result of the new observations was to show that the freezing-point of mercury is only *minus* 40 degrees C., the errors in former experiments having been due to the great contraction of the mercury in the thermometer in passing into the solid state. From this it followed that the enormous natural and artificial colds which had generally been believed in had no proved existence. Still the possible existence of a zero of temperature very different from that deduced from gas thermometry had the support of such distinguished names as those of Laplace and Lavoisier. In their great memoir on "Heat," after making what they consider reasonable hypothesis as to the relation between specific heat and total heat, they calculate values for the zero which range from 1,500 degrees to 3,000 degrees below melting ice. On the whole, they regard the absolute zero as being in any case 600 degrees below the freezing-point. Lavoisier, in his "Elements of Chemistry," published in 1792, goes further in the direction of indefinitely lowering the zero of temperature when he says, "We are still very far from being able to produce the degree of absolute cold, or total deprivation of heat, being unacquainted with any degree of coldness which we cannot suppose capable of still further augmentation; hence it follows we are incapable of causing the ultimate particles of bodies to approach each other as near as possible, and thus these particles do not touch each other in any state hitherto known. Even as late as the beginning of the nineteenth century we find Dalton, in his new system of "Chemical Philosophy," giving ten calculations of this value, and adopting finally as the natural zero of temperature *minus* 3,000 degrees C.

In Black's lectures we find that he takes a very cautious view with regard to the zero of temperature, but as usual is admirably clear with regard to its exposition. Thus he says: "We are ignorant of the lowest possible degree or beginning of heat. Some ingenious attempts have been made to estimate what it may be, but they have not proved satisfactory. Our knowledge of the degrees of heat may be compared to what we should have of a chain the two ends of which were hidden from us and the middle only exposed to our view. We might put distinct marks on some of the links, and number the rest according as they are nearest to or further removed from the principal links; but not knowing the distance of any links from the end of the chain we could not compare them together with respect to their distance, or say that one link was twice as far from the end of the chain as another." It is interesting to observe, however, that Black was evidently well acquainted with the work of Amontons, and strongly supports his inference as to the nature of air. Thus, in discussing the general cause of evaporization, Black says that some philosophers have adopted the view "that every palpable elastic fluid in nature is produced and preserved in this form by the action of heat. Mr. Amontons, an ingenious member of the late Royal Academy of Sciences, at Paris, was the first who proposed this idea with respect to the atmosphere. He supposed that it might be deprived of the whole of its elasticity and condensed and even frozen into a solid matter were it in our power to apply to it a sufficient cold; that it is a substance that differs from others by being incomparably more volatile, and which is therefore converted into vapor and preserved in that form by a weaker heat than any that ever happened or can obtain in this globe, and which therefore cannot appear under any other form than the one it now wears, so long as the constitution of the world remains the same as at present." The views that Black attributes to Amontons have been generally associated with the name of Lavoisier, who practically admitted similar possibilities as to the nature of air; but it is not likely that in such matters Black would commit any mistake as to the real author of a particular idea, especially in his own department of knowledge. Black's own special contribution to low-temperature studies was his explanation of the interaction of mixtures of ice with salts and acids by applying the doctrine of the latent heat of fluidity of ice to account for the frigorific effect. In a similar way, Black explained the origin of the cold produced in Cullen's remarkable experiment of the evaporation of ether under the receiver of an air-pump by pointing out that the latent heat of evaporization in this case necessitated such a result. Thus, by applying his own discoveries of latent heat, Black gave an intelligent explanation of the cause of all the low-temperature phenomena known in his day.

After the gaseous laws had been definitely formulated by Gay-Lussac and Dalton, the question of the absolute zero of temperature, as deduced from the properties of gases, was revived by Clement and Desormes. These distinguished investigators presented a paper on the subject to the French Academy in 1812, which, it appears, was rejected by that body. The authors subsequently elected to publish it in 1819. Relying on what we know now to have been a faulty hypothesis, they deduced from observations on the heating of air rushing into a vacuum the temperature of *minus* 267 degrees as that of the absolute zero. They further endeavored to show, by extending to lower temperatures the volume or the pressure coefficients of gases given by Gay-Lussac, that at the same temperature of *minus* 267 degrees the gases would contract so as to possess no appreciable volume, or, alternatively, if the pressure was under considera-

* Abstract of a Presidential Address delivered at the Belfast meeting on September 10, 1902, of the British Association for the Advancement of Science.

tion, it would become so small as to be non-existent. Although full reference is given to previous work bearing on the same subject, yet, curiously enough, no mention is made of the name of Amontons. It certainly gave remarkable support to Amontons' notion of the zero to find that simple gases like hydrogen and compound gases like ammonia, hydrochloric, carbonic and sulphurous acids should all point to substantially the same value for this temperature. But the most curious fact about this research of Clement and Desormes is that Gay-Lussac was a bitter opponent of the validity of the inferences they drew either from his work or their own. The mode in which Gay-Lussac regarded the subject may be succinctly put as follows: A quick compression of air to one-fifth volume raises its temperature to 300 degrees, and if this could be made much greater and instantaneous the temperature might rise to 1,000 or 2,000 degrees. Conversely, if air under five atmospheres were suddenly dilated, it would absorb as much heat as it had evolved during compression, and its temperature would be lowered by 300 degrees. Therefore, if air were taken and compressed to fifty atmospheres or more, the cold produced by its sudden expansion would have no limit. In order to meet this position, Clement and Desormes adopted the following reasoning: They pointed out that it had not been proved that Gay-Lussac was correct in his hypothesis, but that in any case it tacitly involves the assumption that a limited quantity of matter possesses an unlimited supply of heat. If this were the case, then heat would be unlike any other measurable thing or quality. It is, therefore, more consistent with the course of nature to suppose that the amount of heat in a body is like the quantity of elastic fluid filling a vessel, which, while definite in original amount, one may make less and less by getting nearer to a complete exhaustion. Further, to realize the absolute zero in the one case is just as impossible as to realize the absolute vacuum in the other; and as we do not doubt a zero of pressure, although it is unattainable, for the same reason we ought to accept the reality of the absolute zero. We know now that Gay-Lussac was wrong in supposing the increment of temperature arising from a given gaseous compression would produce a corresponding decrement from an identical expansion. After this time the zero of temperature was generally recognized as a fixed ideal point, but in order to show that it was hypothetical a distinction was drawn between the use of the expressions, zero of absolute temperature and the absolute zero.

The whole question took an entirely new form when Lord Kelvin, in 1848, after the mechanical equivalent of heat had been determined by Joule, drew attention to the great principles underlying Carnot's work on the "Motive Power of Heat," and applied them to an absolute method of temperature measurement, which is completely independent of the properties of any particular substance. The principle was that for a difference of one degree on this scale, between the temperatures of the source and refrigerator, a perfect engine should give the same amount of work in every part of the scale. Taking the same fixed points as for the Centigrade scale, and making 100 of the new degrees cover that range, it was found that the degrees not only within that range, but as far beyond as experimental data supplied the means of comparison, differed by only minute quantities from those of Regnault's air thermometer. The zero of the new scale had to be determined by the consideration that when the refrigerator was at the zero of temperature the perfect engine should give an amount of work equal to the full mechanical equivalent of the heat taken up. This led to a zero of 273 degrees below the temperature of freezing water, substantially the same as that deduced from a study of the gaseous state. It was a great advance to demonstrate by the application of the laws of thermodynamics not only that the zero of temperature is a reality, but that it must be located at 273 degrees below the freezing-point of water. As no one has attempted to impugn the solid foundation of theory and experiment on which Lord Kelvin based his thermodynamic scale, the existence of a definite zero of temperature must be acknowledged as a fundamental scientific fact.

LIQUEFACTION OF GASES AND CONTINUITY OF STATE.

In these speculations, however, chemists were dealing theoretically with temperatures to which they could not make any but the most distant experimental approach. Cullen, the teacher of Black, had indeed shown how to lower temperature by the evaporation of volatile bodies, such as ether, by the aid of the air-pump, and the later experiments of Leslie and Wollaston extended the same principle. Davy and Faraday made the most of the means at command in liquefying the more condensable gases, while at the same time Davy pointed out that they in turn might be utilized to procure greater cold by their rapid reconversion into the aëriform state. Still the chemist was sorely hampered by the want of some powerful and accessible agent for the production of temperatures much lower than had ever been attained. That want was supplied by Thilorier, who in 1835 produced liquid carbonic acid in large quantities, and further made the fortunate discovery that the liquid could be frozen into a snow by its own evaporation. Faraday was prompt to take advantage of this new and potent agent. Under exhaustion he lowered its boiling-point from *minus* 78 degrees C. to *minus* 110 degrees C., and by combining this low temperature with pressure all the gases were liquefied by the year 1844, with the exception of the three elementary gases, hydrogen, nitrogen and oxygen, and three compound gases, carbonic oxide, marsh gas, and nitric oxide; Andrews some twenty-five years after the work of Faraday attempted to induce change of state in the uncondensed gases by using much higher pressures than Faraday employed. Combining the temperature of a solid carbonic acid bath with pressures of 300 atmospheres, Andrews found that none of these gases exhibited any appearance of liquefaction in such high states of condensation; but so far as change of volume by high compression went, Andrews confirmed the earlier work of Natterer by showing that the gases become proportionately less compressible with growing pressure. While such investigations were proceeding, Regnault and Magnus had completed their refined investigations on the laws of Boyle and Gay-Lussac. A very important series of experiments was made by Joule and Kelvin "On the Thermal Effects of Fluids in Motion" about 1862, in which the thermometrical effects of passing gases under compression through porous plugs furnished important data for the study of the mutual action of the gas molecules. No one, however, had attempted to make a complete study of a liquefiable gas throughout wide ranges of temperature. This was accomplished by Andrews in 1869, and his Bakerian Lecture "On the Continuity of the Gaseous and Liquid States of Matter" will always be regarded as an epoch-making investigation. During the course of this research Andrews observed that liquid carbonic acid raised to a temperature of 31 degrees C. lost the sharp concave surface of demarcation between the liquid and the gas, the space being now occupied by a homogeneous fluid which exhibited, when the pressure was suddenly diminished or the temperature slightly lowered, a peculiar appearance of moving or flickering striæ, due to great local alterations of density. At temperatures above 31 degrees C. the separation into two distinct kinds of matter could not be effected even when the pressure reached 400 atmospheres. This limiting temperature of the change of state from gas to liquid Andrews called the critical temperature. He showed that this temperature is constant, and differs with each substance, and that it is always associated with a definite pressure peculiar to each body. Thus the two constants, critical temperature and pressure, which have been of the greatest importance in subsequent investigations, came to be defined, and a complete experimental proof was given that "the gaseous and liquid states are only two distinct stages of the same condition of matter and are capable of passing into one another by a process of continuous change."

In 1873 an essay "On the Continuity of the Gaseous and Liquid State," full of new and suggestive ideas, was published by van der Waals, who, recognizing the value of Clausius' new conception of the Virial in Dynamics, for a long-continued series of motions, either oscillatory or changing exceedingly slowly with time, applied it to the consideration of the molecular movements of the particles of the gaseous substance, and after much refined investigation, and the fullest experimental calculation available at the time, devised his well-known Equation of Continuity. Its paramount merit is that it is based entirely on a mechanical foundation, and is in no sense empiric; we may therefore look upon it as having a secure foundation in fact, but as being capable of extension and improvement. James Thomson, realizing that the straight-line breach of continuous curvature in the Andrews isothermals was untenable to the physical mind, propounded his emendation of the Andrews curves—namely, that they were continuous and of S form. We also owe to James Thomson the conception and execution of a three-dimensioned model of Andrews' results, which have been of the greatest service in exhibiting the three variables by means of a specific surface afterward greatly extended and developed by Prof. Willard Gibbs. The suggestive work of James Thomson undoubtedly was a valuable aid to van der Waals, for as soon as he reached the point where his equation had to show the continuity of the two states this was the first difficulty he had to encounter, and he succeeded in giving the explanation. He also gave a satisfactory reason for the existence of a minimum value of the product of volume and pressure of the Regnault isothermals. His isothermals, with James Thomson's completion of them, were now shown to be the results of the laws of dynamics. Andrews applied the new equation to the consideration of the coefficients of expansion with temperature and of pressure with temperature, showing that although they were nearly equal, nevertheless they were almost independent quantities. His investigation of the capillary constant was masterly, and he added further to our knowledge of the magnitudes of the molecules of gases and of their mean free paths. Following up the experiments of Joule and Kelvin, he showed how their cooling coefficients could be deduced, and proved that they vanished at a temperature in each case which is a constant multiple of the specific critical temperature. The equation of continuity developed by van der Waals involved the use of three constants instead of one, as in the old law of Boyle and Charles, the latter being only utilized to express the relation of temperature, pressure and volume, when the gas is far removed from its point of liquefaction. Of the two new constants one represents the molecular pressure arising from the attraction between the molecules, the other four times the volume of the molecules. Given these constants of a gas, van der Waals showed that his equation not only fitted into the general characters of the isothermals, but also gave the values of the critical temperature, the critical pressure and the critical volume. In the case of carbonic acid the theoretical results were found to be in remarkable agreement with the experimental values of Andrews. This gave chemists the means of ascertaining the critical constants, provided sufficiently accurate data derived from the study of a few properly-distributed isothermals of the gaseous substance were available. Such important data came into the possession of chemists when Amagat published his valuable paper on "The Isothermals of Hydrogen, Nitrogen, Oxygen, Ethylene, etc.," in the year 1880. It now became possible to calculate the critical data with comparative accuracy for the so-called permanent gases oxygen and nitrogen, and this was done by Sarrau in 1882. In the meantime a great impulse had been given to a further attack upon the so-called permanent gases by the suggestive experiments made by Pictet and Cailletet. The static liquefaction of oxygen was effected by Wroblewski in 1883, and thereby the theoretical conclusions derived from van der Waals' equation were substantially confirmed. The liquefaction of oxygen and air was achieved through the use of liquid ethylene as a cooling agent, which enabled a temperature of *minus* 140 degrees to be maintained by its steady evaporation *in vacuo*. From this time liquid oxygen and air came to be regarded as the potential cooling agents for future research, commanding as they did a temperature of 200 degrees below melting ice. The theoretical side of the question received at the hands of van der Waals a second contribution, which was even more important than his original essay, and that was his novel and ingenious development of what he calls "The Theory of Corresponding States." He defined the corresponding states of two substances as those in which the ratios of the temperature, pressure and volume to the critical temperature, pressure and volume respectively were the same for the two substances, and in corresponding states he showed that the three pairs of ratios all coincided. From this a series of remarkable propositions was developed, some new, some proving previous laws that were hitherto only empiric, and some completing and correcting faulty though approximate laws. As examples, he succeeded in calculating the boiling-point of carbonic acid from observations on ether vapor, proved Kopp's law of molecular volumes, and showed that at corresponding temperatures the molecular latent heats of vaporization are proportional to the absolute critical temperature, and that under the same conditions the coefficients of liquid expansion are inversely proportional to the absolute critical temperature, and that the coefficients of liquid compressibility are inversely proportional to the critical pressure. All these propositions and deductions are in the main correct, though further experimental investigation has shown minor discrepancies requiring explanation. Various proposals have been made to supplement van der Waals' equation so as to bring it into line with experiments, some being entirely empiric, others theoretical. Clausius, Sarrau, Wroblewski, Batteli, and others attacked the question empirically, and in the main preserved the co-volume (depending on the total volume of the molecules) unaltered while trying to modify the constant of molecular attraction. Their success depended entirely on the fact that, instead of limiting the number of constants to three, some of them have increased them to as many as ten. On the other hand, a series of very remarkable theoretical investigations has been made by van der Waals himself, by Kammerlingh Onnes, Korteweg, Jaeger, Boltzmann, Dieterici, and Rienganum, and others, all directed in the main toward an admitted variation in the value of the co-volume while preserving the molecular attraction constant. The theoretical reductions of Tait lead to the conclusion that a substance below its critical point ought to have two different equations of the van der Waals type, one referring to the liquid and the other to the gaseous phase. One important fact was soon elicited—namely, that the law of correspondence demanded only that the equation should contain not more than three constants for each body. The simplest extension is that made by Reinganum, in which he increased the pressure for a given mean kinetic energy of the particles inversely in the ratio of the diminution of free volume, due to the molecules possessing linear extension. Berthelot has shown how a "reduced" isothermal may be got by taking two other prominent points as units of measurement instead of the critical co-ordinates. The most suggestive advance in the improvement of the van der Waals equation has been made by a lady, Mme. Christine Meyer. The idea at the base of this new development may be understood from the following general statement: van der Waals brings the van der Waals surfaces for all substances into coincidence at the point where volume, pressure and temperature are nothing, and then stretches or compresses all the surfaces parallel with the three axes of volume, pressure and temperature until their critical points coincide. But on this plan the surfaces do not quite coincide, because the points where the three variables are respectively nothing are not corresponding points. Mme. Meyer's plan is to bring all the critical points first into coincidence, and then to compress or extend all the representative surfaces parallel to the three axes of volume, pressure and temperature until the surfaces coincide. In this way, taking twenty-nine different substances, she completely verifies from experiment van der Waals' law of correspondence. The theory of van der Waals has been one of the greatest importance in directing experimental investigation and in attacking the difficult problems of the liquefaction of the most permanent gases. One of its greatest triumphs has been the proof that the critical constants and the boiling-point of hydrogen theoretically deduced by Wroblewski from a study of the isothermals of the gas taken far above the temperature of liquefaction are remarkably near the experimental values. We may safely infer, therefore, that if hereafter a gas be discovered in small quantity even four times more volatile than liquid hydrogen, yet by a study of its isothermals at low temperature we shall succeed in finding its most important liquid constants, although the isolation of the real liquid may for the time be impossible. It is perhaps not too much to say that, as a prolific source of knowledge in the department dealing with the continuity of state in matter, it would be necessary to go back to Carnot's cycle to find a proposition of greater importance than the theory of van der Waals and his development of the law of corresponding states.

(To be continued.)

ROYAL DANISH PORCELAIN.

THE Royal Porcelain Manufactory was established in 1779, at which time the three blue waved lines were adopted as the trade-mark; later a crown and the words "Denmark" or "Royal Copenhagen" were added in green. Until the close of the eighteenth century the manufactory chiefly imitated the works of Meissen, Berlin and Fürstenberg. From the beginning it produced the blue-mussel painted china, so called from the shell which serves as a handle to the covers. The pattern is painted by hand, whereby it obtains the individual stamp, with cobalt color; it is afterward glazed and finally burnt. The decoration, which is covered by the glaze, is absolutely imperishable. This china now includes two qualities of finer make, namely, "lace edge" and "half-lace edge."

In 1883 the manufactory was established in new premises and steps were taken to gain new markets. The same underglazing technic, which was applied in the first manufacture of the mussel painted china, was

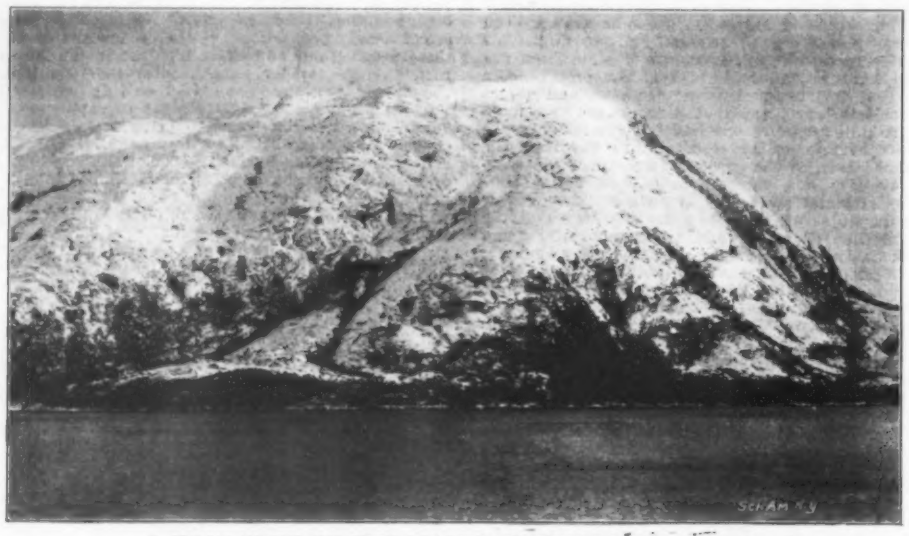
continued, but in addition to the blue color, green and tints of red were included; later on other less important colors were added. In 1898 the manufactory was enlarged, enabling it to produce half as much again. It has been represented at all of the various expositions, and was awarded the grand prix at Paris in 1900 and also placed as number two of the competitors. At the Paris exhibition, beside having a wide selection of patterns of porcelain with liquid glaze, the factory exhibited modeled animals.

PUNTA ARENAS: THE MOST SOUTHERLY TOWN ON THE GLOBE.

By ERNEST C. ROST.

(Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.)

THERE are certain fascinating emotions attached to the hope that one is about to visit some supposedly "out-of-the-world place." My hopes were about to be realized in that respect when four days out from Montevideo (which city is on the same latitude as the Cape of Good Hope), and headed almost due south on one of the palatial steamers plying between Europe and South America, brought us one day's run to Punta Arenas, the most southerly town on the globe, which is some seven thousand and two hundred and two miles from New York.



A NEAR VIEW OF THE ISLAND OF TIERRA DEL FUEGO.

"Go south" to escape the cold winter months does not hold good when we refer to the southern part of South America. The following must seem to many as a strange quotation from my July diary:

"July 26.—Dense fog in the morning. Running at reduced speed. Afternoon clear and cold.

"July 27.—Snow squalls during the night; compelled to lie to several hours.

"July 28.—Heavy fall of snow; compelled to anchor off the entrance to the Straits of Magellan. Noon cleared; proceeded and sighted Cape Dungenes at 1:30 P. M."

These dates correspond with our midsummer, but in the southern hemisphere they represent midwinter. The Atlantic entrance to the Straits of Magellan measures twenty miles across, therefore we cannot see land on both sides as our steamer enters the Straits. Cape Dungenes on our right, toward the north, we have but a glimpse of for a few moments, owing to the almost constant snow squalls. We can, however, make out the lighthouse, which has just been completed and which will prove such a boon to the navigator. Appropriations for its construction were made many years ago; but as it is situated on a point of land just on the boundary between Argentine and Chile, two countries which apparently are not on very friendly terms, its completion was delayed from year to year; that does not seem strange, however, considering we are in South America.

Making the entrance of the Straits is always attended with great danger on account of great sand banks; in fact, coming from the north a detour of many miles must be made quite south of the entrance in order to make the channel. Then, too, thick weather, snow or fog is usually encountered.

Our first view of the shores along the Straits reminded me of the Palisades along our own noble Hudson, but upon drawing closer the delusion was dispelled. The vegetation is very scant and consists chiefly of a low scrubby pine and the dwarfed Antarctic beech, for we are entering the Antarctic regions. Having passed ten miles of this kind of scenery, and having seen not a sign of life of any kind save one small coasting vessel flying the Argentine flag—a very welcome sight, however, in this dismal and far-away part of the globe—we entered "Broad Reach," which varies from twenty-five to forty miles from the continent to the shores of the island of Tierra del Fuego, which we see on our left. Tierra del Fuego means "Land of Fire," and was so named by Magellan on account of the many fires built along the shores by the Indians, on the approach of Magellan's fleet, it being an Indian custom to build these fires upon the approach of a vessel. It may be of interest to state that this custom still exists. During my recent visit to the Philippines, we observed many fires along the shores, which were extinguished as soon as our steamer had passed.

Fernando Magalhaens, or Magellan, as we are wont to call him, discovered and entered the Straits on October 21, 1520, taking thirty-seven days to make the passage through and losing one of his ships. At present steamers pass through in some thirty-six hours. This body of water was named by its discoverers, "The Straits of the Eleven Thousand Virgins." After passing Broad Reach and experiencing one of the local squalls called "williwaws," the Straits narrowed again, and we could plainly make out the fair hills of the great island of Tierra del Fuego, which is not, as is generally supposed, by any means entirely covered with snow and ice, there being valleys and plains covered with grass and streams of good water which afford sustenance for the immense droves of sheep raised on the island by English capitalists. The heaviest expense these sheep raisers have is from losses occasioned to their flocks by severe snowstorms, when the snow so completely covers the grass that it is impossible for the sheep to find any food, and starvation is the inevitable result, the grass being too short to cut for hay. I afterward found that the same trouble existed in the great "pampas" on the mainland about Punta Arenas.

We now come to where the Straits narrow to about one and one-half miles, and find the country quite uninteresting. Low hills with flat lands along the shores, all a gloomy dark gray color save the large tracts of snow, with here and there a valley covered with a scant growth of Antarctic vegetation as already described.

THE STRAITS OF MAGELLAN.

At sundown, at this season 3 P. M., we find ourselves off Punta Arenas (Sandy Point), which town, as viewed from the deck of our vessel as we come to anchor one-half mile off shore, appears lying upon a low flat plain with a background of snow-covered mountains one thousand feet in height, a bleak, dreary, uninviting place. Punta Arenas was founded in 1843 as a penal settlement. In consequence of the rapid increase of traffic through the Straits, all mail steamers having adopted this route and calling at this port, the Chilean government, seeing its growing importance as a port of call and coaling station, in 1868 made grants of land to immigrants and sent out some three hundred settlers, and after that no more convicts were sent.

In 1888 the population was some two thousand, and to-day is fully nine thousand. Coal is mined a few miles from the town, the mines being reached by a tram line. This coal is of the Cretaceous formation, burning quickly, thus not being a good steam coal; it is claimed, however, that better coal is under this stratum. This place is interesting because it is the largest settlement in southern Chile or Patagonia, as we find it on our maps of commerce, and it is the only one in the Straits of Magellan. There is, if you please, a "town" still farther south, but it is a misuse of the word *town*. Puvenier is the name of this spot, and it is just south of Punta Arenas across the Straits on the island of Tierra del Fuego. It is a small settlement of herdsmen, where only a very few white people are ever found, and they only stop long enough to inspect the camps.

At Punta Arenas we are cut off from all news of the world save that brought by steamer, there being no cable communication. It is two thousand miles to the nearest town, either on the east or the west coast of South America. As we are in South America, it seems needless to say that we are transferred in small boats to the dock, there being but one or two exceptions in all the harbors on the vast continent. But if you come from some northern port on the east coast of South America, where there is generally a goodly supply of Yellow Jack, etc., you will be surprised how very strictly the quarantine laws are enforced in this far-away place. Every vestige of your baggage is disinfected, and how thoroughly you can only appreciate after having been here. Everything is literally steamed through and through, resulting in the ruin of your wardrobe; surely, at any rate, you must wear after landing the same clothes in which you left the ship until you replenish your wardrobe at one of the many stores here, or at best until your clothes have been returned from the laundry. The landing here is made on a long but low wooden dock, and we find walking, owing to the deep snow, difficult. I noticed a tram line running the full length of the pier, which is used to carry the merchandise to the large warehouses. A quarter of a mile walk brings us to the Kosmos Hotel, which is the most southerly hotel on the globe; it is a two-story building of wood and corrugated iron. It was a cold walk, and the red-hot iron coal stove in the office of the hotel was a very welcome sight. This "office," by the way, would be called in our country the barroom; and if one wishes a good subject on barroom or drink, South America would be a good place.

The hotel is kept very clean, indeed, and has large and light rooms, and exceptionally good meals are served here. While mostly all buildings are of wood and one story in height, the town is not nearly the dreary place I imagined from my view of it from the steamer. There are four and five-story buildings of brick and one brownstone house that would do credit to our own Fifth Avenue; it has on one side a very fine conservatory. Here, as in all South American cities, the point from which everything is reckoned is the central plaza, a small square on one corner of which is being erected a very fine stone church. Here are the banks, of which there are three, a large building of wood occupied as fire headquarters, and last, but not least, we find here the American consular agency, which office, however, was held during my visit by an Englishman, who was an excellent substitute for an American. I found only three Americans in the place. One was engaged in the lumber business, importing the same from the United States; one had a general merchandise store, and is a pioneer settler of this place; the other was a commercial man only temporarily here. I found here, as in all other parts of South America, that by far the greatest amount of trade is done by foreigners, especially by the English and Germans.

Punta Arenas has the reputation of being a settlement of criminals and of low characters generally. While it is true that one finds human driftwood of all sorts and nationalities here, the truth, however, is that it is a wonderfully live business place with a quiet, orderly population. As there is no extradition treaty between Chile and some other countries, one finds desperate characters here, but no more than in other ports where many vessels call. The town has three clubs worthy of mention; they are the Casino Español, the German Club and the British Association. At all of these travelers are most hospitably received; at the latter club I spent several very pleasant evenings and met the substantial merchants and business men of the town, and I soon became convinced that in Punta Arenas can be found as fine a class of thorough gentlemen as anywhere. Many a fond recollection have I when I think of acquaintances made there. The reading rooms of the club are well supplied with periodicals, magazines, etc. There are two newspapers published in the town, but they are, of course, only of local interest.

The great tall Patagonian we do not see in the town any more than we would expect to see American Indians in our cities save when the circus comes to town. Instead, we see a cosmopolitan population, and street scenes such as we have in any of our towns of like size. Here are electric lights for the streets as well as in the biuldings; and such wide streets! Great wide boulevards they are, in fact. Goods are transported in great two-wheeled carts or on a sled drawn by horses or very large oxen.

Punta Arenas is a free port and has become quite a trading center much used by the crews and stray passengers on all vessels calling here, and goods are sold remarkably cheap. I paid fifty cents for a pair of gloves that could not be duplicated home for less than two dollars and fifty cents; other goods are sold in about like proportion. Among wares of all descriptions that were on sale here, was the best collection of maps and charts I ever saw offered for sale. Souvenirs are sold, such as glass arrows, beads, little grass baskets made by the Patagonians, spears and innumerable other nicknacks such as one finds where Indian souvenirs are for sale; but many of these that were on sale here, at some time or other had been in some unsuspecting, honest New England town.

The principal industry is sheep raising; next to that comes the ostrich farming. Large numbers of these birds are raised in the surrounding country. This, however, is not the true ostrich, but the rhea. They are caught by the natives with a bola, which consists of a thin rope with a weight attached to each end, and which is dexterously thrown around the neck of the bird, strangling him, and after the desired plumes are removed he is released. Just think, ladies, what suffering these birds undergo to supply the graceful plumes. Gold is found in considerable quantities, and a prediction that this part of the world will come prominently to the front ranks of gold-producing fields is a safe one. Among the possibilities here is the establishment of a towing company for the purpose of towing sailing craft through the Straits. No sailing vessels ever attempt this passage now, being obliged to go around by the way of Cape Horn, which is on an island two hundred miles to the south. If sailing vessels could be towed through this passage, there would be a saving to them of many hundreds of miles, and they would thus avoid the tempestuous weather usually encountered of Cape Horn.

The total distance from the Atlantic to the Pacific Ocean via the Straits is only three hundred and fifteen miles. The current is about seven knots per hour, the winds baffling, and as the Straits are so extremely narrow in some places, hardly one mile wide, the impracticability of sailing vessels making the passage unless they are towed is readily conceived. Then, too, navigation by night is almost impossible, and at best extremely hazardous; thus steamers anchor over night, and there are but few good anchorages in the Straits, the water being of too great a depth in most places.

I took passage at Punta Arenas on board the "Karnac" of the Kosmos Line, flying the German flag; the steamer left at the low-vitality hour of 4 o'clock in the morning. From this point the scenery of the Straits becomes more and more interesting as the mountains become higher. About five hours steaming brings us to Port Famine, which at one time was a Spanish penal settlement, but which is now entirely deserted. Soon we are abreast of the wreck of the steamer "Cordillera," from which point we have a good view of Cape Froward, the most southerly point of the South American continent proper. It is a bleak rock some five hundred feet in height joined by a low neck of land to a great range of snow-covered hills averaging about two thousand five hundred feet. Cape Froward is about the middle of the Straits, and after rounding it we have the first glimpse of the majestic Andes. Soon after leaving Cape Froward astern we come to anchor at 2:30 P. M., owing to darkness, in Glacier Bay. Here we find fairly good anchorage in thirty fathoms of water.

Almost due south from here and on the island of Tierra del Fuego is the most prominent peak visible from the Straits, Mount Sarmiento, fully seven thousand feet in height, near which towers another high peak, Mount Darwin. Glacier Bay is an indentation on the Cordova Peninsula at the beginning of that part of the Straits known as Long Reach. Soon we pass innumerable small islands and bays with unpronounceable names or such cheerless ones that I shall not give many. A few are Desolation Island, Last Hope Inlet, Fatal Bay, Escape Reach, Port Famine, Last Wreck Point, No Hope Inlet, Thieves Island, Dislocation Harbor, Fury Islands, Xaultegua Gulf, etc. Through this section the Straits are very narrow, winding and crooked, but as we draw near King William the Fourth Land they widen considerably, and we enter Sea Reach, where the waters measure from the continent side to the islands on our left fifteen miles. Now we steam close to the land on the north called Queen Adelaide Archipelago, and from there looking due west we see Cape Pillar, which is on the extreme point of Desolation Island. This long island as seen from the deck of our steamer presents a long line of ragged peaks all covered with a mantle of the purest white snow from their summits to the very water's edge. This cape forms the southern point of the Pacific entrance to the Straits of Magellan, the northern point being the islands of Direction, or as they are called the Evangelists, where there is a lighthouse. We are now completely surrounded, with the exception of the narrow entrance where we have a glimpse of the Pacific, with absolutely white mountains. I found the water so calm and still that these beautiful snow mountains were perfectly reflected in the waters; in truth, they seemed to be floating in the waters. It was in fact a symphony in white, or better still a symphony in pearl, the sky being of the most delicate blue with small white clouds, which in turn were reflected in the still waters, giving the impression that you were not only looking up into but down into the skies, and yet this part is always mentioned as being among the roughest and most tempestuous the navigator ever encounters; it will also be remembered that when Magellan entered the ocean here he called it, on account of its still, calm waters, the "Pacific."

So even here in this far-away part of the world, where not a sign of life is seen save an occasional albatross or a few seals along the shores, and where in case of shipwreck one must almost certainly perish, as no life-sustaining food is to be found on shore, there is a redeeming feature; in fact, one is entirely oblivious to any of the dangers, for he is entirely occupied in admiring the magnificent scenery. Nature seems to excel here in the beauty of her scenery and atmospheric effects, notwithstanding that all is snow and ice and ice-cold water.

Large steamers pass into the Pacific from here, but I chose the German line for the reason that they take the inner or Smyth Channel route, which is a body of water between a series of many islands off the coast of Chile and the mainland. These steamers select this route for the reason that they thus avoid the rough seas on the outer course. This line is a very important one, running direct from Hamburg to Punta Arenas, then via the Straits of Magellan and the Smyth Channel route along the entire west coast of South America as far south as Panama, making stops at all towns of any consequence, and proceeding to San Francisco. The trip north from the Straits via the Smyth Channel reveals a variety of scenery not equaled anywhere. There may not be any one view equal to the Bolivian Andes, and yet here we see the Andes rise out of the very waters themselves, and they seem higher and loftier as seen from the surface of the water than do the giants of Peru and Bolivia, which we can only see when we are at a very great altitude ourselves.

But the weird scenery all along this great waterway stamps it without any exception as the wonderland of the world.

WHITE GIANT PETAURIST IN THE ZOOLOGICAL GARDENS AT BERLIN.

SOME ANIMALS AT THE ZOOLOGICAL GARDENS IN BERLIN.

By DR. L. HECK.

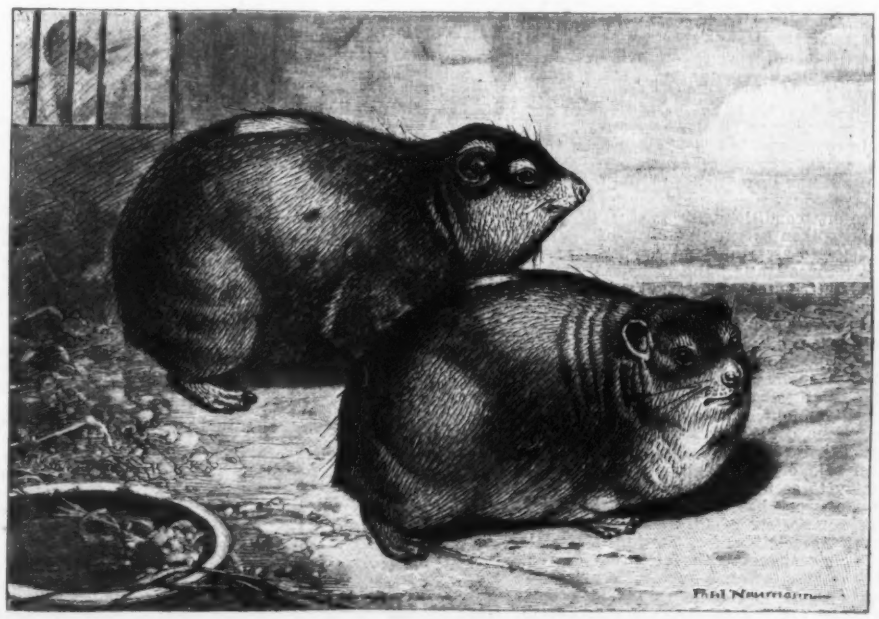
A WHITE Giant Petaurist.—The reader must not conclude from the caption that we are actually dealing with a gigantic animal; it is only a giant among its nearest relatives, which are dwarfs, its size exceeding but little that of our squirrel, although it appears much larger than the latter, owing to its extended body and the wing membrane which is stretched between the fore and hind legs.

This membrane, which is hairy and is unlike the naked flying organs of the bat, enables it to make long and wide floating leaps from tree to tree, the termination of which is, however always lower than the starting point. It recurs with mammalia in arboreal rodents, the flying squirrels, and forms in the order of marsupials the common peculiarity of some climbing, nocturnal genera, classed together as Petaurinæ. As said before, no actual flying, as in the case of the bat, can be done by these animals, but they can with outstretched wing-membrane, which acts as a parachute, calmly float down from the top of one tree to the lowest branches or the trunk of another, in order to climb up on it again. According to the reports of observers, they exercise this faculty with a skill which in the bright moonlight nights of Australia affords a highly interesting and fascinating aspect.

The Petaurinæ furnish another striking proof of the fact that the whole order of the marsupials is not at all uniform or similar in subsistence and mode of living, but is merely held together by peculiar conditions of propagation. The various forms of marsupials in Australia utilize all possibilities of existence offered, in a very similar manner as the remaining mammals in other parts of the world, which leads even to such remarkable antitypes as the Petaurinæ constitute to the rodent group of the flying squirrel.

Otherwise, the petaurist belongs to the herbivorous, climbing marsupial family of the Phalangeridæ, whose best-known type, the cat-sized vulpine phalanger (Phalangista vulpina L.), called Australian opossum by the fur dealers, is a common sight in the Zoo. The genuine marsupial squirrel (Petaurus sciureus Desm.), a little animal, not even of the size of the fat dormouse, is likewise frequently kept. Our large giant petaurist (Petauroides volans L.), however, is very rare, and the one drawn by Neumann in a most lifelike manner is the second one that I have seen and kept. It is especially interesting on account of the fact that it is snow-white; nevertheless it is not a perfect albino, for the eyes and edges of the ears are black.

Two Klipdas Varieties.—The layman might take the two little quadrupeds illustrated herewith for a pair of guinea pigs. But upon closer inspection, the fine profile of the head, which has nothing of a rodent-like character, will startle him, likewise the round, perfectly hoof-like ending of the feet—veritable tapir or rhinoceros feet reduced to dwarf size. As a matter of fact, the klipdas or daman (German Klippschliefer, literally cliff-creeper), thus named because the best-known varieties live similarly to the dormouse, are the nearest relatives of the rhinoceros. Especially the dentition is entirely rhinoceros-like. The old anat-



KLIPDAS IN THE ZOOLOGICAL GARDENS AT BERLIN.

omist Meckel, of Halle, was exceedingly vexed that his contemporary, Cuvier, of whom he otherwise did not think much, found that out before him. Down to the present day these peculiar little animals are among the most interesting objects of investigation for the anatomist because on the other hand they exhibit many rodent-like traits, even to strictly scientific observation, in their soft parts and their manner of living—they creep between rocks and climb trees. Unfortunately, palæontology fails us completely when we ask for extinct ancestors of the klipdas in the history of the earth; and therefore, as I have already stated in my "Thierreich," their existence can meanwhile be taken merely as a proof of the fact that there are in the animal kingdom transitions, not only between similar smaller groups, but also between large orders as dissimilar as the Ungulata (hoofed animals) and the rodents.

Whatever may be one's opinion on colonial politics, the most fanatic opponent even cannot gainsay that Germany's African colonies have furnished rich material to science. Especially modern systematization has made it a point, with much zest and success, to increase, by means of colonial collection, our knowledge of the African fauna, materially assisted by the scientific travelers, the officers of the garrisons and the colonial officials, among whom zoological tendencies are happily constantly on the increase. The hindmost of our two klipdas, which came from German Southwest Africa, is also a present from First Lieutenant Volkmann, one of the best hunters and zoologists among the officers of the protective troops. Thus the material for study constantly arriving from the colonies and increasing knowledge have divided the klipdas into several genera and a large number of varieties, which, though little different in outward appearance, are often very much so in mode of living and anatomical details (skull, dentition and number of teats). Above all, the klipdas proper are distinguished after Gray from the arboreal variety (German: Baumschliefer, genus Dendrohyrax), which, despite their blunt ungulate feet, seem to be excellent climbers; at least they are said to live exclusively in treetops and liana mazes. Oskar Neumann on his first trip carefully observed and collected a new variety, named after him by Matschie, on the rarely-visited eastern coast of Zanzibar in such surroundings.

The klipdas proper (genus Hyrax, or if the older term is preferred, Procavia) live on the ground, or rather in the mountains between rocks, similar to the dormouse; they only differ in that they seem to move rather in a jumping manner from cliff to cliff. Basing upon material differences of dentition, another genus, viz., Heterohyrax, has been separated. Each is represented in our illustration, excellently drawn by P. Neumann; in front the Nubian klipdas (Procavia Burtoni Gray) of rather monotonous gray coloring; in the background the darker variety from Southwest Africa (Heterohyrax Bocagei Gray). In the latter I was especially struck by the long stiff bristles, which are distributed in groups over the whole body, pushing apart, in the places where they come out, the remaining fur to such an extent that seemingly a dark spot ensues. Characteristic of all klipdas is a light-colored spot on the back; it enables one to immediately recognize the fur, which is latterly sometimes worn by colonial ladies.

Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Illustrirte Zeitung.

THE TESTING OF CEMENT.

SOME difference of opinion exists as to the chief purpose to be attained by the testing of cement. There are engineers who contend that the objective is not the establishment of standards, but the certainty that given brands of cement will conform with specified requirements. According to this view, the end is not to compare one brand of cement with others, but to determine whether the maker of an accepted brand has fulfilled the promised conditions throughout the whole of the material delivered. Other engineers and investigators attach importance to the attainment of a system of examination calculated to afford uniform results for uniform qualities of cement when examinations are conducted by different individuals. This second way of looking at the subject is certainly more comprehensive than the first, and it is not easy to conform with the ideal it expresses. Hitherto, no entirely satisfactory system has been devised which will eliminate the personal equation from the conduct of tests, and variations must, therefore, occur, rendering the results not only relative, but more or less inaccurate. We have also to remember that while most other materials of construction are tested as finished products, cement is tested in a form made by the tester, and not by the manufacturer, or even by the user. Hence the result obtained in every case is false, having been qualified by variable and indeterminate co-efficients, arising from the actual skill and experience of the tester, and from variations of the water used and of the temperature and laboratory conditions. To use a simple illustration, we may liken existing methods of cement testing to an attempt to ascertain and compare the properties of flour by investigating the chemical, physical, and mechanical attributes of bread made by different bakers, or of cakes made by different housewives. Just as the same quality of flour will give varying results when mixed by persons of varying temperament and skill, and cooked in ovens of varying characteristics, so one sample of cement will give differing results under different treatment. Yet a near approach to uniformity might be attained if chemical and physical condftions could be standardized, and if manual preparation were replaced by mechanically applied treatment. No organized attempt has been made in this country to secure uniformity of tests, although a great deal of work has been done in this direction by the American Society of Civil Engineers and the International Association for Testing Materials. The subject is now engaging the attention of the laboratories of the "Pontes et Chaussées" service in France, the Royal Testing Laboratory at Charlottenburg, in Germany, and the testing laboratory at Zurich. Hope may therefore be entertained that some definite conclusions may be approached before long. In the meantime there is every reason for believing that existing methods afford sufficiently adequate safeguards for architectural and engineering practice, and much useful information may be derived from a study of the records available. A somewhat lengthy paper recently read before the Franklin Institute, Philadelphia,* presents an excellent summary of the various systems of examination adopted, and a valuable series of notes upon the characteristics of Portland cement.

While the author puts forward a plea for uniform methods of examination, he does not attempt to formulate a system of his own. After some preliminary remarks of more or less historical nature, he proceeds to trace the development of modern testing methods, and acknowledges in Mr. Grant, the engineer for the Metropolitan Main Drainage Scheme, the pioneer of systematic examination. The tensile testing machine devised by Mr. Grant formed the basis of modern machines of similar class, and his work was ably followed up by Faija, Michaelis, and other investigators. After a brief reference to the development of testing methods, the author proceeds to consider in detail various matters to which we may usefully allude.

Before any testing operations are undertaken, the user must determine the place at which the examination shall be conducted, this point being left by the author to be decided according to circumstances. There is no doubt whatever that from the time the clinker is reduced to powder its physical and chemical properties are constantly undergoing changes which affect the quality of the cement as a building material, and even after it has been made into mortar similar changes take place. Therefore it cannot be expected that tests conducted at the destination of a consignment will yield results precisely similar to those obtained at the maker's works. As the user is concerned chiefly with the quality of the cement when received by him, it seems the most natural course that it should be examined at the place where it is to be used. If foreign-made cement is employed, such procedure is absolutely necessary; but in the case of home-made cement tests can often be performed at the maker's works, or when brands of known reliability are bought the manufacturer's certificate may be accepted. When important works are concerned check tests should be made upon the site, if the original tests have been carried out elsewhere. Upon the subject of sampling cement received the author presents some useful notes, suggesting that the general condition of every consignment should be carefully observed, so that it may be ascertained whether the cement has become caked, lumpy, or has been otherwise damaged during transit, also recommending that samples should be taken from the heart of each package. The latter stipulation is important, as the quality of the outer layers may be impaired, and the shaking due to transportation tends to separate the coarser particles. This method of sampling leads to a reliable indication of the properties of the cement, although it is, if anything, somewhat in favor of the maker.

On the general subject of testing, Mr. Humphrey says that the simplest methods yield the most uniform tests, an opinion that will be indorsed by every one having practical experience of such work. Purely scientific investigation usually requires expensive and complicated apparatus and the expenditure of much time for the determination of obscure points. Practical tests, on the other hand, should be few in number and simple in execution, for they need not do more than establish the essential characteristics of the material. While chemical analysis rarely forms part of a commercial test, the scheme given in the paper to which we refer will be of interest to those who wish to obtain for themselves data as to the composition of different qualities of cement. In the ordinary way, the most important chemical test is that for sulphuric anhydride, and we may here mention that some Continental specifications demand the rejection of cement containing more than 1 per cent of anhydride, which is equal to 1.7 per cent of calcium sulphate. The latter substance is sometimes added by manufacturers for the purpose of securing good results under the ordinary test for soundness, with the effect that cements so treated may show subsequent decrease of strength when exposed to the air in the form of mortar. As a general rule the qualities for determination are—fineness, activity, soundness, and strength; but in the comprehensive paper now before us other properties of cement are considered in detail.

In dealing with the question of fineness, the author chiefly confines his remarks to methods of sieving. The fineness of cement can be much more accurately ascertained by air separation with the aid of an apparatus such as the "fluorometer" lately described in our columns. The latter mode of separation is favorably mentioned by the author, who thinks it "not improbable that it will eventually supersede the unsatisfactory method by sieves." Fineness of grinding, we may remark, is chiefly a matter of economy, if the strength of the mortar or concrete afterward made be duly taken into account, for finely-ground cement will stand a larger proportion of sand than coarsely-ground material. Very often, however, when two such samples are tested neat, the coarse cement will give results as high as the finer quality; and unless inquiry be made as to the strength of the mixture of cement and sand, it is certain that unexpected weakness will follow. Referring to the specific gravity of cement, the author says that this property is of considerable value in detecting adulterations. He does not add that specific gravity is the only true test for thoroughness of burning, apparently assuming his readers to be already aware of the fact. The test for specific gravity is not recommended, except in permanent laboratories, as it is one requiring considerable skill and accuracy. Le Chatelier's apparatus is mentioned as the most convenient for this test, being also less liable to error from retained air bubbles and leakage at the connections than most other forms. A common test, intended to show the activity of cement, is to observe the time required for setting. Information as to the activity of a cement is necessary, for its strength will be seriously impaired if the mortar be disturbed after it has commenced to solidify. Various automatic appliances have been devised for recording the setting of cement, but for ordinary use the most suitable apparatus appears still to be the Vicat needle. The time of setting can only be determined approximately, as it is affected by prevailing conditions, and in the case of slow-setting cements it will be variously estimated by different observers. Sometimes, as an auxiliary test, the rise in temperature during the setting of a cement paste is recorded, but this test is valueless and misleading except in the hands of an expert. One of the difficulties at present in the way of uniform results is the absence of a standard consistency for the cement paste, used in some ordinary tests. Ideas upon consistency vary in different countries, and frequently according to individual fancy. Perhaps the most rational method of fixing the proper proportion of water to be used is to adopt the normal consistency apparatus, in which the condition of the paste is judged by the penetration of a weighted rod. Other methods are generally primitive in the extreme, and seem to be altogether out of place in these days of scientific precision. For instance, the percentage of water is sometimes determined by mixing the cement to a sirupy paste, so that it will run from a knife in thin threads without forming lumps. Another way is to mould the paste into a ball which is then dropped from a height of 1 foot, and if it does not crack, or flatten materially, the consistency is said to be correct. In this case everything depends upon interpretation of the term "materially."

Passing on to consider tests of strength, the author correctly observes that the shape of the briquette is very important, and he appends an illustration showing various briquette sections suggested by Grant, and the final one recommended by him which has been generally adopted in this country. The form advocated by the American Society of Civil Engineers, and that adopted in France and Germany, are also illustrated in the same plate. It may be remarked that the section adopted in America would be improved by rounding off the sharp corners, as these render molding unnecessarily troublesome. The section used in France and Germany, consisting of two rounded heads with a nicked neck, is intended to assist fracture in the central part, but as the author says, experience does not show that this effect is attained in practice.

Mixing is another operation in which mechanical devices afford little help to the tester of cement. The objection to most mixing machines, on the part of the author, is to be found in the tendency of the material to "ball," and in the difficulty of telling when the process is completed. A certain amount of experience is always necessary to ensure the proper mixing of cement for testing. Mr. Humphrey mentions that he has known an inexperienced person to continue working upon cement which had actually set, while wondering why he could not get the mass into a plastic condition. It is true that many cements appear dry when first mixed, becoming quite wet after having been kneaded for a few minutes, but such a case is different from that of a batch which gradually becomes mealy and non-adhesive. The latter conditions indicate that setting has commenced, and the mass should be thrown away. Operators will do well to bear in mind the caution given by Mr. Humphrey as to the atmospheric conditions of the room where mixing is performed. A high temperature and dry air have the effect of causing "checks," or air cracks, and of checking the process of hardening, as well as of reducing tensile strength. Some of the illustrations of mechanical mixing machines are worthy of notice, particularly the "Faija" mixer, and one used at the Cornell laboratory.

Molding is another operation in which hand manipulation is generally preferred to machine work. Here, again, there are openings for variable results, but as a matter of fact greater uniformity of density can be secured by hand than by machine molding. The objections stated by the author against mechanical molding are: That the operation is very slow; that with existing appliances it is only possible to form one briquette at a time; and that uniform density cannot be ensured owing to insufficient control over the pressure, and to the fact that pressure is applied from one side only. A useful practice recommended by the author is to weigh all briquettes before immersion in water, rejecting those which vary more than 3 per cent from the mean weight. Some serviceable, practical hints upon the preservation of briquettes are given in the paper. For the twenty-four hours' test briquettes are sometimes simply covered by a damp cloth. This is clearly inadvisable, for, as the author remarks, the cloth may become dry in some places, and in others its contact may make the briquettes too moist. If a cloth be used at all it should be placed over a wire screen, but the most suitable appliance for preserving briquettes is the moist closet. For the longer time tests, the briquettes are immersed in water after twenty-four hours' exposure in moist air. It is still a matter of opinion whether running water has solvent action sufficient to reduce the strength of cement appreciably within the short period of immersion adopted for testing purposes. Mr. Humphrey is inclined to think it has not, for he has noticed that the loss is just as great in still water. As a rule, the use of pans for still-water immersion will be found most convenient for preserving briquettes upon the site of works, while tanks provided with more elaborate arrangements for water supply and overflow are desirable for permanent laboratories.

When the briquette comes to be broken in the testing machine, differences of preparatory treatment must be represented in the records, although it is quite possible that they may not always be recognized. As the author truly says, it often happens that the last molded, and usually the densest briquettes, are broken at twenty-four hours or seven days, and the first molded, or less dense, at twenty-eight days or longer. Then the tests may show an apparent falling off in strength, and thus lead to incorrect conclusions. Again, the cement may have begun to set before the last briquette was molded, giving indications upon testing of reduced strength or even of disintegration. Other false results may have their origin in cross strains due to improper centering, in too sudden application of the load, or in the absence of proper bear-

* "The Inspection and Testing of Cements." By Richard L. Humphrey. The Journal of the Franklin Institute, Philadelphia, 1901-2.

ing owing to particles of foreign matter on the clips, or on the briquettes themselves.

The soundness of cement is of paramount importance, and numberless methods have been suggested for ascertaining the extent to which this property exists in any given sample. In the paper under discussion, only the well-known Faija hot-water test is mentioned, since this is now practically universal. It appears that in America the test in question, especially when temperature is raised to the boiling point, is the *bête noir* of the cement manufacturer, who uses sulphate of lime as an adulterant in his endeavor to make the material pass the required ordeal. In the opinion of competent judges, the rational and careful use of sulphate of lime is desirable to render cement slow setting, while excessive admixture is clearly to be deprecated. Mr. Humphrey appears to fully realize the difficulties which are attendant upon hot water or boiling tests, and he suggests the sample pats should be immersed in water, maintained at a temperature not exceeding 170 deg. Fahr., after setting hard, for a period of twenty-four hours. At the end of that time well-made Portland cement should develop no objectionable qualities, the cement ought also to be perfectly sound in cold water. The suggestion comes as a mean between accelerated tests and the normal test adopted in Germany, which is as follows: Small pats of the cement are made and allowed to stand twenty-four hours in damp air, and are then placed, some in water and some in the air, and observed until twenty-eight days old. If they do not become distorted or cracked during that time, the cement is considered to be sound. The opinion of Mr. Humphrey is that this test is not sufficient to develop the unsoundness of cement in time to be of practical value. On the other hand, after a lengthy investigation, the German Society of Cement Manufacturers recently arrived at the conclusion that the normal test is not of less value than the so-called accelerated tests. As the Society in question includes the heads of all the important departments of public works in Germany, and the head of the German testing laboratory, this expression of opinion is one that cannot be readily set aside. Yet, as the accelerated test is of sufficiently trying character to induce manufacturers to admix substances with the object of enabling cement to pass muster, we are inclined to think that the test ought not to be abandoned. It can certainly be employed with advantage by the manufacturer for his own information and guidance, and by the user for similar purposes, and if it were no longer regarded as affording a criterion by which the acceptable or non-acceptable character of a cement should be judged, there would be no temptation for the manufacturer to add an excess of sulphate of lime in his product. A difficulty attending tests for soundness is found in making the pats. On this point Mr. Humphrey makes the practical remarks that, "Simple as the making of these pats may appear to be, it is extremely difficult for inexperienced persons to make them correctly. Pats may be so troweled as to give initial strains which develop cracks during the test." If the pats should dry out shrinkage will follow, giving an impression of unsoundness, and if the cement should set before the pat is finished the lifting of the outer edge may mislead the inexperienced. The soundness and constancy of volume of cement is undoubtedly of great importance, but from what we have said it will be realized that room for improvement still exists in connection with tests for its determination.

Beyond the tests made for ascertaining the acceptable quality of cement as delivered for use, there are many others which belong more properly to the regularly equipped laboratory. Operations for determining compressive, transverse, and adhesive strength, and others for ascertaining the effects of frost, sea water, and porosity are extremely useful, for they are the means of contributing general information for the guidance of those concerned in the design of structures where cement is used. With regard to the ordinary tests, it may be remarked that the interpretation of results is not the least of the difficulties to be encountered. It is never possible to insist upon an exact compliance with the terms of a specification, because it is difficult to define the influence of fortuitous circumstances connected with testing. For example, as the author hints, the sand used may be of poor quality, water used in mixing may have been excessive or deficient in quantity, the strength of the briquettes may be affected by drying out, or by the conditions under which they were preserved. Again, the operator may not apply the same amount of energy to each test, the influence of this factor being particularly remarkable when a large number of tests is in question. Altogether, there can be no doubt that present methods of testing are capable of improvement. It is nevertheless equally clear that the practical trials demanded by engineers have been largely responsible for the very great improvement in the quality of cement that has taken place during the past twenty years. What we now want is the formulation of a scheme by the aid of which uniform and readily comparable tests can be obtained, and we trust that the deliberations to which allusion has previously been made may conduce to so desirable a result.—The Builder.

COMPOUND LOCOMOTIVES ARE TWENTY-FIVE YEARS OLD.

IT is now the twenty-fifth anniversary of the application of the compound system to locomotives in France, says Machinery. The first compound locomotives were designed by A. Mallet and operated on the railway between Bayonne and Biarritz, France. They were built at the Creusot works and had one high-pressure and one-low pressure cylinder, with provisions for working either simple or compound. In that year the Institute of France awarded to Mallet the Fourneyron prize for mechanics, in consideration of his achievement. The use of the compound locomotive has extended throughout Europe since its introduction by Mallet and it is estimated that nearly 15,000 are now in operation on various European roads, of which two-thirds are of the Mallet type. In marked contrast to the development of the compound system abroad is the growth of compounding in this country. The first compound engine of any consequence to be tried in the United States was Dunbar's five-cylinder compound, which first ran on the Boston & Albany Road in 1883, or six years after the successful introduction of Mallet's locomotives in France. Dunbar's engine was a failure and compounding made no progress here until 1888-9. In these years Webb's three-cylinder compound was tried on the Pennsylvania Railroad; the first Baldwin-Vauclain compound was built for the Baltimore & Ohio Railroad, and the first Schenectady compound having an intercepting valve to allow high-pressure steam to be used in the low-pressure cylinder was introduced.

CHAMOIS SKINS.

By HERBERT T. BLAKE.

WITHOUT intention to deceive, this name, strictly speaking, is a misnomer as applied to skins commonly sold as "chamois." It is now the peculiar process in preparation that gives the skin its name.

The Rupicapra Tragus, the chamois of the Alps of southern Europe, long ago lost to the sheep of England, France and Australia its supremacy as the chief source of the "chamois skin."

The chamois is a little animal not larger than a small goat, the largest seldom weighing over seventy-five pounds. It is the only member of the antelope family now inhabiting the continent of Europe. Its skin is used almost exclusively for rugs and gloves, and is of exceptional value because of its very fine texture and its uniformity in thickness. In this latter respect it is superior to all other skins used for similar purposes. These characteristics make it of great value as a "chamois," but its high cost and small size are disadvantages which make the less expensive, larger and nearly equally soft and durable sheepskin an all-conquering competitor.

The doe-skin, which has been stated to be the source of the best grade of "chamois," is not now used for this purpose, being more suitable for the manufacture of gloves. The part of the pelt of the sheep used as the "chamois" is the under skin, termed the "flesher," which was, until comparatively recent years, discarded as of little commercial value. This is secured by splitting the skin through the center by a machine especially constructed for this purpose. The upper of the two skins thus produced is termed the "grain" or "skiver," and is used in the manufacture of thin, fancy leather for book-binding, portfolios, etc.

Before it is ready for splitting the skin must pass through the preliminary processes necessary in the preparation of leather. As taken from the sheep the skin is first thoroughly cleansed of blood and dirt by steeping in water for a few hours and then washing for a short time in a wash-wheel or tumble, a large rotating perforated drum.

The wool is now removed by one of the various methods, the most common of which is by the use of lime. This consists in placing the skins in a pit filled with milk of lime and alternately drawing them out and putting them back until the wool is easily removed. A series of pits is usually used, the strength of the solutions gradually increasing from a very weak solution in the first to one that is quite strong, the skins being immersed in each in the order of their strength. The milk of lime dissolves the epidermis, and also swells the fibers of the skin and splits them up into their consistent fibrils, both of which effects are necessary in the production of good leather, or "chamois." This process is termed "swelling," "raising," or "plumbing."

The lime is now removed by immersing the skins in a dilute acid solution and dissolving out with water the salt thus formed. It is, perhaps, more commonly the practice to secure this result by a method known as "bating" or "puering," which consists in placing the skins in a solution of hen dung or excrements of dogs and subjecting them to the action of the enzymes which bacteria have formed together with the compound ammonias which have resulted from their action on the organic matter present. By this process not only is the lime removed, but also other results obtained which are not fully understood but which certainly tend to improve the quality of the resulting skin. Efforts are being made to find a substitute for this disgusting mixture, and a solution containing pepsin, finely cut meat, meal, etc., is used to some extent, and is claimed to give equally good results.

If an acid solution was used, the skins are covered with whiting to neutralize the excess of acid, and then after the whiting is removed the skins are in shape for splitting.

At the present time, both because of the high price of the domestic skins and because they are coarser in texture and less easily split than the foreign, very few if any are split in this country, practically all of this being done in England, France and Australia. The skins in this splitting machine move with lightning rapidity, cutting only a very small part of the skin at each movement.

In the process of "chamoising," the flesher is first thoroughly drenched and then placed in the trough of a fulling machine and pounded with large mallets until nearly free from water, and its fibrous structure has become loose and open, sawdust usually being used to facilitate the process.

Fish oil, usually codfish oil, is then sprinkled over the skins. After being wrapped in bundles of about four each they are again pounded or "milled" until the oil is evenly and thoroughly distributed. They are now hung up, and after partly drying are again oiled, milled and dried, this process being repeated again and again until they are thoroughly saturated with oil, it having replaced all moisture and foreign matter. From three to five gallons are used for each one hundred skins. The value of the finished skins depends very largely upon the quality of the oil used in this process, and the care taken to prevent the skins being over-heated during the milling.

The skins at this point are hung in a room having but slight ventilation, and kept warm and at an even temperature by steam heat for several days. A slight fermentation takes place, which dilates the pores and promotes an even more thorough incorporation of the oil with the animal fiber, resulting in the formation within the skin of a sort of "oleate of gelatin." This thorough incorporation serves to make the fibers of skin non-adhering, thus preventing its hardening on drying, which is due to the adhesion of the fibers. The excess of oil is removed by pressure and saponification with an alkali, as potassium hydrate, and then the skin is hung in the open air to dry.

The skin is now of that deep yellow color characteristic of the chamois, no coloring agent being used during any part of the process. It is, however, stiff and hard to the touch and in every way, except in color, quite unlike the finished chamois.

To develop the soft, velvety skin to which we are accustomed, this is first stretched and worked by a process called "staking," over a post tipped with a wedge-shaped piece of steel, the edge of which is rounded. To aid in getting the necessary purchase and to prevent abrasion of the skin, the right leg of the man at work is bare from a little above the knee to the ankle.

The skin, after this process, is soft and flexible, but its surface is still smooth. "Buffing" or "prizing" is the next and last procedure. The buffer is a corundum wheel about ten inches thick and with a rounded edge. Each portion of the skin is held against this rapidly-revolving stone until its whole surface, either on one or both sides, is slightly raised, giving it the plush-like finish of the commercial chamois.

All domestic skins are trimmed and cut over forms of definite size and shape, but abroad skins are sold in just the shape they leave the buffer. The skins are packed in bundles or kips of thirty each, each kip containing skins all of approximately the same size. The small and imperfect skins are cut to the best possible advantage into many different sizes and shapes. Not the smallest piece is wasted, even the dust from the buffer being used in polishing. The bits cut from the ragged edge are used to polish small pieces of jewelry and for watch pockets, etc.

Double-dressed chamois differ from single-dressed only in being buffed on both sides, this necessitating the use of a skin having no very thin places and therefore requiring their special selection for this purpose.

Chamois of almost every color may be had from the manufacturer, but, due to the difficulty in distributing the dye evenly throughout the whole skin, their price is nearly twice that of the common yellow chamois. In dyeing, the skins are treated with a dilute solution of sodium carbonate to remove oxidized oil left after the tanning process, and then mordanted by drumming in a 1 per cent solution of titanium salts.

In drumming, a rotating drum similar to the contrivance which aids in the washing of the skins is made use of. They are transferred without washing to the dye bath, which is best made in the drum. The colors most suitable are the alizarin colors, James colors and the natural dyestuffs. The goods are run in the dyestuffs solution at a temperature of 45 deg. to 50 deg. C. for about one-half hour, when they are removed and lightly fat-liquored, which consists in rubbing lightly with a specially prepared emulsified oil. After this they are dried.

There are on the market imitations of the chamois, alum, chrome and other tannages being used in tanning the skin. These may readily be distinguished by the peculiar softness and flexibility of the oil-dressed skin, and also by the interior color, which is always dark yellow when freshly cut. Even when bleached the skin retains this property. A good, oil-dressed skin should absorb moisture very readily. When wet it should be treated like a flannel, and when dirty a liberal application of soap is beneficial to the skin. If, after thoroughly washing, it is rinsed in soap-suds, the skin will dry up soft and shrink but a trifle.

The imported chamois cost about 5 per cent more than the American skin, due to their being firmer in texture and therefore less easily stretched, and for these reasons more durable. They are usually preferred for livery use. For light work and toilet use the American chamois is preferable.

A very attractive show window may be made with chamois, but care should be taken to avoid strong sunlight, as it rapidly bleaches the exposed portion of the skin.—The Spatula.

A NEW DEFINITION OF PORTLAND CEMENT.*

By A. D. ELBERS.

FROM the article "Tests and Constitution of Portland Cement," published in the SCIENTIFIC AMERICAN SUPPLEMENT of April 19, 1902, the following definition may be derived:

Portland cement is a sintered compound of clay and lime, which has aproximately the constitution of a half silicate (0.=½:1) with lime for its principal base, and alumina, ferric oxide and alkalies as minor essential constituents. It is an unstable compound which gradually releases under atmospheric influences nearly all of the lime that it holds in excess of a two-thirds silicate (0.=2.-3:1); and it takes up water of crystallization in setting, and thereafter hardens in the air as well as in water without undergoing any material change of volume. Exposed to the air, the set cement hardens principally through the absorption of carbonic acid gas by the liberated lime, and in water it hardens principally through the formation of hydrosilicates out of a portion of those of its constituents that are reacted upon by the liberated lime that dissolves.

The most suitable composition for Portland cement appears to be that which yields in the fire a sintered compound having its chief constituents in such proportions that the oxygen of the silica amounts to half of that of the lime, alumina and ferric oxide, and that the oxygen of the lumina and ferric oxide, added to that of the silica, is equal to that of the lime and magnesium oxide.

Ferric oxide and alkalies, though only desirable in small proportions, have to be considered essential

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

constituents for the following reasons: The ferric oxide, being present in the uncombined state, readily forms during the burning calcium ferrate; and thereby incites the alumina of the clay to assume also the character of an acid constituent, and to bind the remaining free lime. Finally, both sesquioxides are overpowered or subjugated by the silica, and then resume their basic character, which leads to the gradual release of the lime in excess, and to the hardening of the set cement.

The alkalies act during the burning as fluxes, and in the new cement as solvents of silica, which they yield later on to the lime.

All bases that assume under atmospheric influences a higher degree of oxidation, such as the protoxides of iron and manganese, are objectionable constituents.

From a synthetic point of view it might not seem necessary to define Portland cement as a compound of clay and lime, inasmuch as an equivalent substance could, possibly, be produced by substituting free silica and alumina for the clay. But aside from the fact that it is not practicable on account of the cost to use alumina for the composition of a mix unless beauxite is available, it is advisable to adhere to that definition because it indicates the difference between true Portland cement and slag cement that has been burned in the same manner.

Since slag cement is now burned in rotary kilns, whereby the sulphur, the worst feature of the unburned slag-puzzolanes, becomes eliminated, it can only be distinguished from true Portland by its lower specific gravity. As Portland is made by combining hydro-silicate of alumina by hard fritting with nearly twice as much of lime, whereas slag cement is made by combining completely melted compound silicate of lime, alumina, etc., with a much smaller proportion of free lime, the one necessarily undergoes more intense reactions during the burning than the other; and the resulting difference in the density of the respective products is apt to be in most cases a rather accurate indication of their comparative efficiency in the finished state.

ELECTRICALLY-OPERATED AIR COMPRESSORS.

ONE of the most remarkable developments in the recent history of engineering progress is the constantly increasing use of compressed air as a medium of performing numerous and various industrial operations.

Pneumatic tools and other appliances for the utilization of compressed air have been introduced into one field after another with such successful and gratifying results that the advantages of using compressed air for a wide variety of purposes are now fully recognized.

The present general use of electricity renders it advantageous to operate air compressors with electric motors. The convenience and economy of this method is apparent when it is remembered that an electrically-driven compressor can be operated from any lighting power or railway circuit that may be available.

To meet the constantly increasing demand for an electrically-driven, simple, compact air compressing unit, the Christensen Engineering Company, Milwaukee, Wis., are manufacturing a complete line of motor-driven compressors ranging in capacity from 4 to 1,000 cubic feet of free air per minute. The smaller sizes are made for portable as well as stationary service. The following description of these machines will be of interest to our readers.

The type "M" motor-driven air compressor, illustrated herewith, is for stationary continuous service. It is built in capacities from 50 to 1,000 cubic feet of free air per minute.

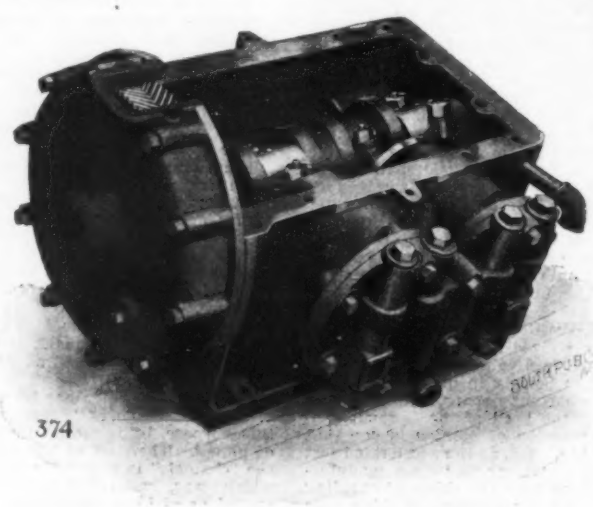
The electric motor and the compressor have been designed to form a compact self-contained unit. The air is compressed in the cylinder, shown on the left, by a double-acting piston which is operated by means of a connecting rod and steel crankshaft. The latter is mounted in bearings located within the frame of the machine. This shaft carries on the motor end a helical gear which is driven by a pinion on the armature shaft of the motor. The entire machine is mounted on a substantial cast iron base.

Both the cylinder and the valve heads are water-jacketed throughout. The clearance spaces have been reduced to the lowest practicable limit, thereby correspondingly increasing the economy.

The suction and discharge valves are arranged in cast iron heads bolted directly to the cylinder. They consist of seamless cold-drawn steel cups, so arranged that each is removable independent of the other. No springs are used with these valves. They are operated by the compressed air itself and are reseated by gravity. The peculiar construction of these valves renders a small lift possible, hence the noise from their operation is reduced to a minimum. The suction and discharge valves are identical and interchangeable. Only one connection is necessary when piping from the compressing cylinder to the reservoir.

The piston is provided with an improved form of packing rings which are carefully fitted in place so that they form as near a perfect sliding joint as can be obtained. The piston rod is of steel, carefully ground true on dead centers. The rod passes through a self-adjusting metallic packing box.

The connecting rod is composed of steel and is arranged to receive oil for lubricating the crank pin, wristpin and piston. The crosshead is provided with adjustable shoes of extra large area and with an accurately ground hardened tool-steel wristpin which fits into a phosphor-bronze bearing in the rod.



TYPE "I" COMPRESSOR WITH MOTOR REMOVED.

The crankshaft is composed of a high-grade steel, and is provided with extra large bearings, thus avoiding the frequent adjustment of the bearing boxes which is usually necessary with bearings of ordinary size. The shaft is carefully balanced and accurately turned true to receive the connecting rod.

The crankshaft is extended at the motor end to carry the gear which is driven by a pinion on the armature shaft of the motor. The gear and pinion are of the helical herring-bone type with teeth cut by special machinery in the most perfect manner, thereby reducing the noise so that it is almost unnoticeable.

The gear case and the crank chamber are connected and form an inclosure which is partly filled with oil, with which all the working parts are automatically and continously lubricated, including the air cylinder. The latter is connected with the oil chamber so that the proper quantity of oil for lubricating the surface between the cylinder and the piston is automatically supplied and no sight-feed lubricator is required. The motion of the crankshaft in the oil causes continuous lubrication of the main bearings, the crankpin bearing of the connecting rod, the crosshead guide, the piston rod, the wristpin in the crosshead and the piston. Oil is also supplied automatically to the bearings at the pinion end of the motor. The gear and pinion operate continuously in the oil bath. The machine will remain lubricated as long as the oil is kept up to a level determined by a filling plug on the side of the crank chamber. Experience has shown that, after being supplied with oil, the compressor runs for several weeks before replenishing is necessary.

Either an alternating or a continuous current motor may be used. The illustrations herewith show the continuous multipolar type that the Christensen Company build for this service. The lower frame of the motor is of cast iron and the field is composed of low-carbon cast steel with detachable steel pole pieces. The motors are series wound and are started and stopped without using resistance of any kind. The armature is of the latest ventilated type, built up of disks of soft steel and slotted to receive the winding. Machine-formed armature coils are used; the insulation and other materials are of the highest grade obtainable. The commutator is built up of hard-drawn bars of the best lake copper insulated from each other by segments of mica. The armature shaft revolves in extra long bronze bearings with ring oiling arrangement. The bearings are so designed that it is impossible for oil to get into the armature.

The brush holder is of the simplest possible construction. It is provided with an instantaneous tension adjuster arranged so that the tension can be increased while the motor is running.

The design of the motor and compressor is such that every part is easily and quickly accessible.

By unscrewing a few bolts the armature and the field coils can be removed or exchanged. The gear, pinion, valves or cylinder heads may also be removed without disturbing any other parts.

Access to the crosshead and wrist-pin is obtained by doors conveniently arranged on the side of the slide frame. The crank chamber is constructed so that it is completely closed, but the upper part may be quickly removed, giving free access to all the working parts, while a smaller handhole covering is provided and may be easily removed for inspection of the interior.

An automatic governor starts and stops the motor compressor at the desired minimum and maximum pressures. It is a very simple piece of apparatus, consisting of an ordinary pressure gage mechanism with a special hand which, upon coming in contact with a conducting stud at the position of minimum pressure, allows current to flow through a magnet coil. This coil operates a plunger to which the contact pieces for the motor circuit are attached, thereby closing the circuit and starting the motor.

As soon as the pressure reaches the desired maximum, the hand strikes another stud and current passes through a second solenoid magnet, thereby pulling the plunger in the opposite direction and opening the motor circuit. By this mechanism it is possible to get a close margin between maximum and minimum pressures. This margin is readily adjusted by moving the contact studs.

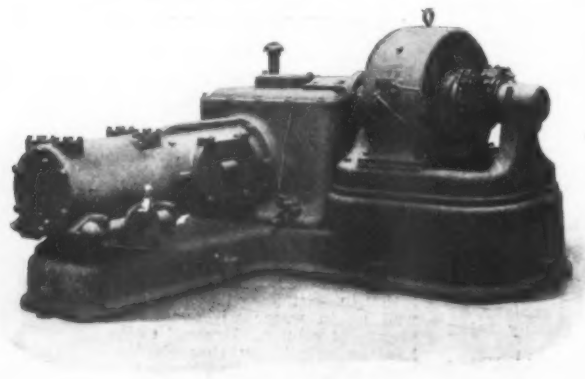
The governor is provided with a magnetic blowout for extinguishing the arc and preventing the burning of the contact pieces.

All the working parts are easily accessible for inspection, and the governor is protected by a cover not shown in the illustration.

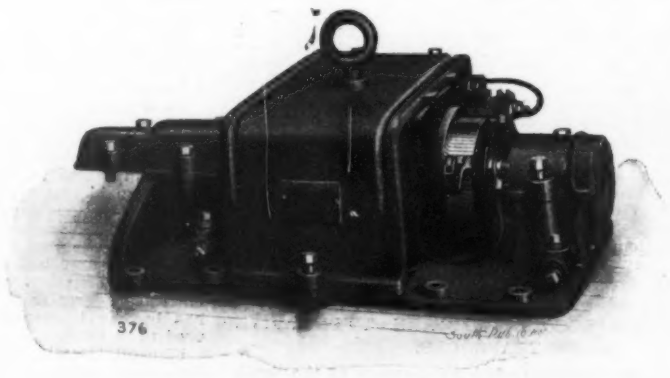
A smaller compressor for stationary continuous service is built in capacities from 4 to 35 cubic feet of free air per minute.

These are known as type "L," and they are similar in design and construction to type "M," described above. The motor is mounted directly over the compressor instead of on the side. The compressor has two cylinders which are water-jacketed throughout. Each cylinder is provided with a single-acting plunger piston which is operated by a connecting rod from a well-balanced steel crankshaft. The shaft is extended at one end to carry a helical gear which is driven by a pinion on the armature shaft of the motor directly above. The base of the motor forms a cover for the compressor frame, and the gears are also inclosed in a suitable casing. The interior of the compressor is therefore completely inclosed and protected from injury. This compressor is a modification of the type "H," the water-jacketing feature being added to make it suitable for continuous service.

The suction and discharge valves are of seamless



TYPE "M" COMPRESSOR. CAPACITY, 75 CUBIC FEET PER MINUTE.

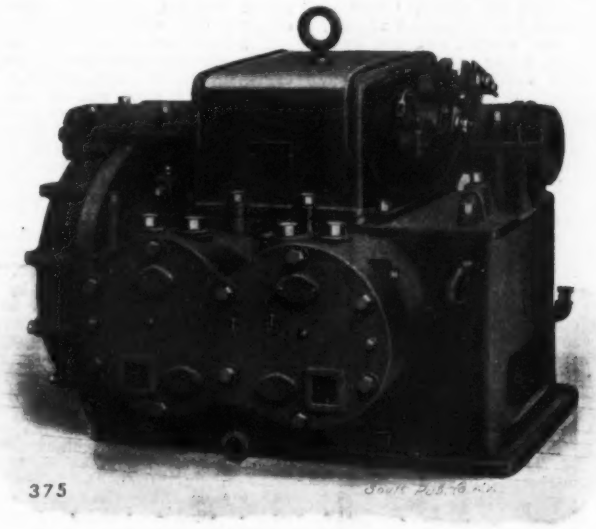


MOTOR FOR TYPES "L" AND "I" COMPRESSORS.

cold-drawn steel. They are conveniently arranged in the cylinder back cover, so that each is independent of the other and separately accessible.

The illustrations of the type "L" herewith show the well-known continuous current type that the Christensen Company have made for several years for use with their air-brake equipments on electric cars. They are four-pole series-wound motors with two field coils. They have cast-steel frames and cast-steel poles. All the other important features of the motor are similar to those used with the type "M" compressors.

For portable service, the Christensen Company mount their type "H" compressor with the automatic governor and air reservoir on a suitable hand truck which can be easily and quickly moved wherever necessary. This portable outfit, known as type "I," has a very wide field of usefulness wherever pneumatic tools or other compressed-air appliances are used and an expensive system of piping is not desirable. The



TYPE "L" COMPRESSOR.

compressor is taken to the work instead of transmitting the compressed air from a stationary compressor at a distance.

These compressors are frequently mounted on a wagon instead of a hand truck and transported by horses, for use in drilling and bonding rails, etc., in electric railway or other work where electric power can be obtained. It is only necessary to make a connection to the trolley wire by a hook or pole for the purpose of obtaining power for the motor.

It is also practicable to make the smaller sizes of the type "M" portable, especially where the truck, upon which the compressor is mounted, is arranged to run on rails.

THE WORLD'S TELEGRAPHS.

"THE Submarine and Land Telegraphs of the World" is the title of a monograph prepared by the Treasury Bureau of Statistics. It presents some information regarding the submarine telegraphs of the world, which is especially interesting at this time in view of the prospective construction of an all-American cable across the Pacific. It shows that the submarine telegraphs of the world number 1,750. Their aggregate length is nearly 200,000 miles; their total cost is estimated at $275,000,000, and the number of messages annually transmitted over them is more than 6,000,000. All the grand divisions of the earth are now connected by their wires, and from country to country and island to island the thoughts and words of mankind are instantaneously transmitted. Beneath all oceans save the Pacific the universal language which this system has created flows uninterruptedly, and man talks as face to face with his fellowman at the antipodes. Darkest Africa now converses daily with enlightened Europe or America, and the great events of the morning are known in the evening throughout the inhabited world. Adding to the submarine lines the land telegraph systems by which they are connected and through which they bring interior points of the various continents into instantaneous communication, the total length of telegraph lines of the world is 1,180,000 miles, the length of their single wires or conductors, 3,800,000 miles, and the total number of messages annually sent over them about 400,000,000, or an average of more than 1,000,000 each day.

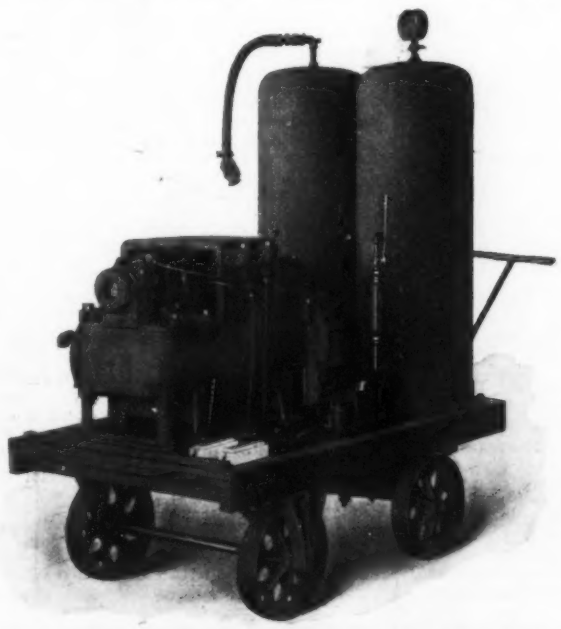
In the short half century since the practicability of submarine telegraphy was demonstrated, the electric wires have invaded every ocean except the Pacific. Nearly a score of wires have been laid across the Atlantic, of which no less than thirteen now successfully operate between the United States and Europe, while three others span the comparatively short distance between South America and the African and south European coast lines. Throughout the Indian Ocean lines connect the Far East with Europe and America via the Red Sea, the Mediterranean, the western coast of Europe and the great trans-Atlantic lines. The Mediterranean is crossed and recrossed in its entire length and breadth by numerous cable lines, and the "Mediterranean of America," the Gulf of Mexico and the Caribbean Sea, is traversed in all directions by lines which bring its islands and colonies into speaking relations with each other and with South America, Central America, the United States and thence with Europe, Africa, Asia—the whole world. Along the eastern coast of Asia cable lines loop from port to port, and island to island, receiving messages overland from eastern Europe via the Russia-Siberian land lines and forwarding them to Japan, China, Australia, New Zealand, the Straits Settlements, Hongkong and the Philippines and receiving others in return. South America is skirted with cable lines along its entire border save the extreme south, where they are brought into intercommunication by land lines. Along the entire coast of Africa cables loop from place to place and from colony to colony, stretching along the entire circumference and penetrating the interior by land lines at various points.

Every body of water lying between the inhabited portions of the earth, with the single exception of the Pacific Ocean, has been crossed and recrossed by submarine telegraph lines. Even that vast expanse of water has been invaded along its margin, submarine wires stretching along its western border from Siberia to Australia, while its eastern borders are skirted with lines which stretch along the western coasts of the two Americas. Several adventurous pioneers in Pacific telegraphy have ventured to considerable distances and depths in that great ocean, one cable line running from Australia to New Zealand, a distance of over 1,000 miles, and another extending from Australia to the French colony of New Caledonia, 800 miles seaward. A cable which is to connect Canada with Australia across the Pacific is now being laid at the joint expense of the United Kingdom, Canada and the Australian commonwealth and has already been completed from Vancouver, British Columbia, to Fanning Island, just south of the Hawaiian Islands, and it is expected that the entire line will be completed by the end of the present year.

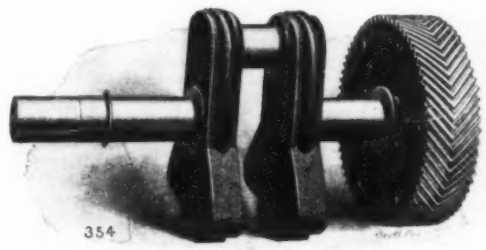
The chief obstacle in the past to the construction of a grand trans-Pacific cable was found in the fact that midocean resting places could not be satisfactorily obtained or arranged for, no single government controlling a sufficient number of suitable landing places to make this seem practicable, in view of the belief that the distance through which messages could be sent and cables controlled was limited. With landing places at Hawaii, Wake Island, Guam and the Philippines, however, no section of a cable stretching from the United States to Asia and touching at these points would have a length equal to that now in daily operation between France and the United States. The length of the French cable from Brest, France, to Cape Cod, Mass., is 3,250 miles, while the greatest distance from land to land on the proposed Pacific route would be that from San Francisco to Hawaii, 2,089 miles; that from Hawaii to Wake Island being 2,040 miles, from Wake Island to Guam 1,290 miles, from Guam to Manila 1,520 miles, and from Manila to the Asiatic coast 630 miles. While the depth of the Pacific is somewhat greater than that at which any cable has been laid, the difference between its depth and the greatest depth reached by cables in the Atlantic would be very slight, the cable recently laid from Haiti to the Windward Islands being in 18,000 feet of water. The recent survey for a cable between the Pacific coast and Manila justifies the belief that a route can be selected in which the depth will not exceed 20,000 feet and may not exceed 18,000 feet. The recent survey made by the Bureau of Equipment, Navy Department, under the direction of Rear-Admiral R. B. Bradford, disclosed the greatest ocean depths heretofore known lying between Midway Island and Guam and being 31,614 feet, or but 56 feet short of six miles depth of water. This depression, however, which has been named the "Nero deep," in honor of the vessel from which the sounding was made, can be avoided by a detour, and it is believed that the necessary depth will not exceed 20,000 feet and may not be more than 18,000 feet.

GERMAN ELECTRICAL MANUFACTURERS.

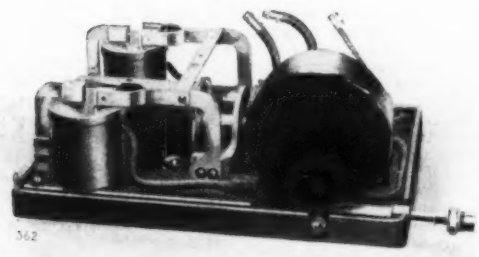
WHAT is called in headlines by the German press "The Catastrophe in the Schuckert Electrical Company" has during the past week recalled public attention sharply to the conditions under which some of the great electrical corporations of Germany were promoted, and the embarrassments which some of the methods employed have more or less inevitably entailed. The event alluded to was a meeting on the 26th instant of the stockholders of the Schuckert Electrical Company at Nuremberg, at which the managers announced that, through depreciation of plant and material, insolvent accounts, and necessary appropriations for a reserve fund to meet further depreciations, the company had suffered losses aggregating 15,500,000 marks, or something more than $3,500,000. As the Schuckert Company is one of the foremost corporations of its class in Europe, with an up-to-date plant and all the accompaniments of a large business, some surprise has been expressed that its affairs should make such a bad showing for its shareholders. The explanation leads back to the fact, now well known here, that the sudden rise of some of the German electrical companies into corporations of vast resources and activities was, in some cases at least, the result of skillful and artificial creation of markets



TYPE "I" COMPRESSOR, WITH COVER REMOVED.



CRANKSHAFT AND GEAR FOR TYPE "M" COMPRESSOR.



AUTOMATIC GOVERNOR.

for products, rather than the supply of an actual and legitimate demand. Concisely stated, some of these companies bought their orders for electrical installations and materials by financial operations that left them shareholders in many enterprises which have since proven less promptly lucrative than had been hoped, and have thus drawn more or less heavily upon the capital of the parent companies. To understand how all this came about, it should be remembered that German progress in electrical science was for a long time far in advance of popular appreciation of its advantages. The companies organized and equipped for the manufacture of lighting and power plants could not wait for the slow growth of public demand for such improvements, and they therefore undertook to finance and erect such installations themselves, confident that, once established and in use, the public would not fail to appreciate them and invest in their securities. This went very well for a time. It created a large and ready market for electrical machinery and materials at high prices, and supplied hesitating municipalities with electric tramways and lighting plants which their citizens greatly enjoyed, but which were built and for a time managed by the electrical manufacturing companies at their own expense. Inevitably, this process of consuming their own capital necessitated heavy loans and frequent increases in the stock of such corporations, together with a steady expansion of their manufacturing capacity. Some of the companies, especially the Schuckert corporation, made enormous investments in electric installations for the manufacture of calcium carbide, putting in the machinery at their own prices but receiving for it little or nothing except stock in the carbide plants. Thus the supply of acetylene material was soon far beyond all legitimate requirements, prices collapsed, and the carbide industry suffered a serious and permanent reverse.

Another heavy blow for some of the German electrical manufacturing companies has been the failure of the storage-battery traction system for tramways, which is now conceded to be practically hopeless. When electric traction was introduced into this country, municipal governments were timid and hesitating. They objected to the overhead conductor because it was considered unsightly and dangerous, and in order to obtain any franchise at all the tramway companies and the electrical manufacturers who were behind them had to agree to furnish cars that would dispense with a visible trolley. This meant either the underground-conduit system—which is so expensive to construct as to be justified only by an enormous traffic—or a reliance upon storage batteries, and the companies generally had recourse to the latter. The extent to which this has been done may be inferred from the fact that one company in Hanover has at present 274 accumulator cars in service. There, as at Halle, Hagen, and many other places, they have been found so heavy, costly, and subject to explosions as to be unremunerative. At Berlin, where many hundreds of them have been in service, all are to be abandoned and recourse had to underground conductors for centrally located streets and overhead wires for the less crowded and suburban sections.

The net result of all these conditions was that some of the electrical manufacturing companies of Germany which had gone on organizing and supplying power, lighting, carbide and other plants, not only at home, but in Russia, Scandinavia, Austria-Hungary and other European countries, were caught with all sail spread by the turning tide and adverse gale that set in during the summer of 1900. In the stormy weather that ensued, most industrial stocks declined sharply, the investing public became alarmed and timid, the failures of the Leipziger and other banks followed a few months later, and led on to the situation of which the meeting of last week at Nuremberg has been the ultimate result.

The encouraging features of the present condition are the fact that the credit of several of the oldest and strongest of the electrical companies remains unshaken, the general feeling that the bottom has been reached, that the obligations entailed by a system of forced development have been mostly liquidated, and that with the good cereal crops that will be harvested this year, peace throughout the world, and the hoped-for renewal of the commercial treaties which are to lapse next year, the foundation will be laid for a renewed and enduring prosperity.—Frank H. Mason, Consul-General at Berlin.

COMPARATIVE ACCELERATION TESTS WITH STEAM LOCOMOTIVE AND ELECTRIC MOTOR CARS.*

By B. J. ARNOLD and W. B. POTTER.

IN connection with the preparation of a report on the use of electricity for the propulsion of trains of the New York Central Railroad in the tunnel entrance and terminal in New York city, an invitation was extended by the General Electric Company to Mr. W. J. Wilgus, chief engineer of the railroad company, to use its experimental track and apparatus at Schenectady, and a series of tests were accordingly carried out under the direction of the authors of this paper. The tests were principally for the purpose of determining the comparison between steam and electric traction on short-haul suburban passenger service. Owing to the short curves in the connecting tracks, the General Electric Company's track could not be used for the steam locomotive tests. The steam tests, therefore, were made on the New York Central main line tracks west of Schenectady.

A steam locomotive was built from the specifications of Mr. A. M. Waite, Superintendent of Motive Power and Rolling Stock of the New York Central, by the Schenectady Locomotive Works. It was designed specially for the rapid acceleration work required in suburban service, being provided with large grate area and heating surface and a very large proportion of weight on its driving wheels.

The two electric motor cars were similar in form, 54 feet over all, each weighing about thirty-five tons including the electrical equipment, which consisted of four "G. E. 55" motors and type M. control. All axles being equipped with motors, the two cars together gave approximately the same weight upon the drivers as the steam locomotive. The acceleration was, therefore, directly comparable for trains of equal net weight, and to secure this comparison the same trail cars arranged in the same order were used in both the steam and electric tests.

In the steam runs the drawbar pull, speed and time were recorded by an Illinois Central dynamometer car, and the same care was used with the electric motor cars to determine the relation between current input and drawbar pull. The dynamometer car had to be returned before the electric runs were completed, but not before a large number of readings were taken, from which curves were plotted showing the relation between amperes and drawbar pull with different weights of train behind the motor cars.

The order of the tests, both steam and electric, was as follows:

A train of six cars, including five standard passenger coaches loaned by the New York Central Railroad, and the dynamometer car, was started and run over a mile of track, acceleration being made as rapidly as possible with the power available. These same runs were repeated, dropping off one car at a time, until only the dynamometer car remained. Automatic records were kept of the drawbar pull, speed, time, distance and the strength and direction of the wind. The condition of rail and the temperature were also noted. The same runs were repeated, using the two motor cars in place of the steam locomotive, the dynamometer car being used in some of the runs and a box car loaded to equal weight in subsequent runs. In the electric runs, additional records were kept of voltage, ampere and wattmeter readings. The wattmeter was not carried on the car, but was placed stationary at the point of feeding the third rail, thus avoiding any inaccuracy due to jarring. The voltage leads of the wattmeter were connected to the extreme end of the third rail and track, thus receiving at all times the exact voltage at the train, so that the energy delivered to the motor cars represented the net input and did not include losses in the feeder system.

The cars used in this test and the weights are given below:

		Pounds.
New York Central locomotive	No. 1407	214,000
General Electric motor car	No. 4	73,000
General Electric motor car	No. 5	70,000
Illinois Central dynamometer car	No. 17	45,640
New York Central coach	No. 1885	48,200
New York Central coach	No. 545	60,250
New York Central coach	No. 1709	53,700
New York Central coach	No. 508	51,450
New York Central coach	No. 1798	54,600

During the tests many runs were made, but for the illustration of this paper, representative and average runs only are given.

ELECTRIC MOTOR CARS NOS. 4 AND 5.

The electric runs were made upon the General Electric experimental track against a head wind of 15 m. p. h. The rail was dry, the temperature 8 deg. C., and the grade practically level. In the middle of the run there was a curve having a minimum radius of 875 min., equivalent to about a 6½ deg. curve, the friction effect of which may be assumed as approximately equivalent to one-tenth per cent up grade of the steam runs.

NEW YORK CENTRAL STEAM LOCOMOTIVE NO. 1407.

All steam locomotive runs were made upon the New York Central main line track west of Schenectady, against an up grade of 0.1 per cent and a head wind of 15 m. p. h. The temperature was 4 deg. C. and the rail wet with a very light falling snow.

Although the locomotive was especially built for suburban or acceleration work, and was provided with a large fire-box, giving it facilities for rapid steaming, the pressure dropped from 200 pounds to less than 185 pounds, during the first part of acceleration. In starting, the throttle was opened wide and steam used full stroke, the engine being hooked up as acceleration proceeded.

While the electric runs had the advantage of drier rails than the steam runs, the driving wheels were not slipped in either instance. Although the steam locomotive was able to give a maximum tractive effort at starting equal to that obtained electrically, this high tractive effort was not maintained, but immediately fell with increasing speed, even with the most expert handling.

As the acceleration curves produced by the steam locomotive and electric motor cars have different shapes, and as in the two tests there was about the same weight upon the drivers, it is interesting to note how well this driver weight was utilized. This is shown by the following tables giving the speed reached in ten, twenty and thirty seconds with equal trailing load for both electric and steam trains.

MILES PER HOUR ATTAINED IN 10 SECONDS.

No. of trailers.	1	2	3	4	5	6
Motor cars No. 4 and 5	22.5	20.7	17.3	14.4	12.6	11.2
Locomotive No. 1407	14	13	12.5	12	10	9.7

MILES PER HOUR ATTAINED IN 20 SECONDS.

No. of trailers.	1	2	3	4	5	6
Motor cars No. 4 and 5	34	32.3	29.4	27.4	24.5	21.2
Locomotive No. 1407	25	21.2	21.5	19.5	18	16.3

MILES PER HOUR ATTAINED IN 30 SECONDS.

No. of trailers.	1	2	3	4	5	6
Motor cars No. 4 and 5	38.2	36.4	34.2	32.4	30.3	28.1
Locomotive No. 1407	31.7	28.2	27.2	24.7	23.2	20.8

An inspection of the tables clearly brings out the fact that the electric motors during acceleration can more effectively utilize the weight upon their drivers than can a steam locomotive. As rapid acceleration is especially important when stops are a mile or so apart, the electric motor has an advantage in being able to cover the same distance in the same time with less energy expended and at less maximum speed than a steam locomotive, owing to its being able to maintain its maximum accelerating rate for a longer period.

The average speed given in both steam and electric tables is the average speed of the train while it is in motion, and does not include time of any stop at the end of the run. Starting from rest, the power was kept full on to the three-quarter mile post where the power was shut off and the brakes applied in such a manner as to bring the train to rest as near the mile post as practicable. In the tests the steam train ran from 5 to 15 per cent over a mile before the train was brought to rest and the electric trains from 2 to 4 per cent, but even with the longer distance the average speed of the steam runs only approached that attained in the electric runs made over a shorter distance. A comparison of the two sets of runs on the basis of average speed is, therefore, not quite fair to the electric motor car, as its average speed would have been considerably higher if the length of the run had been the same as that made with the steam locomotive. An inspection of the tables will show, however, that even with the shorter distance run, the electric motor cars were able to make higher average speeds than the steam locomotive over its longer distance, and these higher average speeds were obtained also with a lesser maximum speed.

The maximum speed of a train making a given run in a given time serves as an indication of its energy consumption. A train, therefore, which is so handled as to make a given run in a given time, with lowest maximum speed, will consume less energy for the run. The electric runs tabulated all show a lower maximum speed and a higher average speed than those runs made with the steam locomotive, and the energy consumption of the electric runs should, therefore, be less for the same service performed than with the steam locomotive.

The motors of an electrically equipped train may be placed upon the trucks of ordinary passenger coaches, each carrying its full complement of passengers, and thus lessen the gross weight by elimination of the locomotive. The true measure of comparison between steam and electrically propelled trains should be the energy per seat mile rather than per ton mile, as the latter value is based upon the total train weight and includes a considerable proportion of dead weight embodied in locomotive and tender. The steam locomotive not only adds to the train weight, the weight necessary to insure traction, but is further handicapped by additional weight on pony trucks and usually a tender.

As an illustration, the following table has been prepared from these tests showing the number of cars in the train, the number of passengers carried (each car seating 64 persons) and the energy which for convenience we have given in watt-hours, required per passenger for both steam and electric runs.

NET ENERGY PER PASSENGER CARRIED.

Number of Cars.	Number of Passengers.	Watt Hours per Passenger Steam.	Electricity.
6	384	43.9	29.7
5	320	52.2	32.1
4	256	57.5	33.5
3	192	77.4	37.5
2	128	108.0	45.2
1	64	187.8	45.2

This table is based upon the actual net energy delivered to the wheels of the train and does not include the losses inherent to any system of operation. The results tabulated may, therefore, be considered as fundamental, and typical of the two systems of operation—the steam locomotive and the electric motor car.

The following table gives the efficiencies for the seven electric runs, the efficiency being the ratio between net energy output to the wheels and total volt ampere input:

EFFICIENCY OF ELECTRIC RUNS.

Trailers.	Average M. P. H.	Watt Hours per Ton Mile Output.	Input.	Efficiency of Run Per Cent.
6	27.2	59.1	79.8	74
5	28.6	61.0	82.0	74.3
4	29.8	63.8	84.9	75.3
3	30.6	68.0	90.2	75.3
2	32	69.6	90.6	69.9
1	33.1	75.3	112.8	66.7
0	34.6	79.8	130.0	61.5

An accurate comparison of the relative efficiency or coal consumption of steam and electric power for similar service would require an extensive series of tests with indicator and dynamometer on the performance of the steam locomotive.

As a matter of interest we have secured an approximate comparison from a single test by weighing the coal and water taken by steam locomotive No. 1407 for a period of 24 hours, covering four trips between North White Plains and Grand Central Station, a distance of 24.75 miles, on the Harlem Division of the New York Central Railroad. The trips occupied about 4 hours, the yard movements about 1 hour, and the locomotive was idle for 19 hours.

Following is a detailed record of the service covering the 24 hours:

NORTH WHITE PLAINS TO GRAND CENTRAL STATION.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective H. P. H.
63.5 minutes	3	21	204 tons	97 tons	129
Lay-over		6 hours.			

GRAND CENTRAL STATION TO NORTH WHITE PLAINS.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective H. P. H.
66.25 minutes	5	17	278 tons	171 tons	255
Lay-over		12 hours.			

NORTH WHITE PLAINS TO GRAND CENTRAL STATION.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective H. P. H.
60.3 minutes	7	13	387 tons	280 tons	251
Lay-over		¾ hour.			

GRAND CENTRAL STATION TO NORTH WHITE PLAINS.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective H. P. H.
59.75 minutes	4	20	256 tons	149 tons	240
Lay-over		1¼ hours.			

Total effective h. p. hours, hauling coaches.....861
Coal consumed .....13,412 pounds.
Coal per effective h. p. hour.....15.6 pounds.

The effective h. p. h. given above is the energy required for movement of the cars only, exclusive of the locomotive, and was determined from the drawbar pull

* A paper presented at the 19th Annual Convention of the American Institute of Electrical Engineers, Great Barrington, Mass.

taken by dynamometer car in previous tests over the same route.

The coal consumption covers all coal burned during the period of 24 hours, not only for movement of cars, but also movement in the yard and the banking of fires during lay-overs.

The effective h. p. h. to move the cars serves as the basis of comparison with electric service, the coal consumed by the locomotive for whatever purpose being properly chargeable to the net work by the locomotive during the period.

The efficiency of an electrical system, as an average under variable load, may reasonably be assumed as follows:

Engine	90 per cent Efficiency.
Alternator	92 per cent Efficiency.
High Potential Transmission	98 per cent Efficiency.
Transformers	97 per cent Efficiency.
Converters	92 per cent Efficiency.
Third Rail	95 per-cent Efficiency.
Motors, including control.	75 per cent Effi. 51.33 p.c.

This percentage of effective horse power output of motors to i. h. p. of engine will vary somewhat, depending on the load factor. As an even figure we will assume an efficiency of 50 per cent.

Coal consumption per indicated h. p. h. from actual records of electrical power stations, is in some cases less than 2 pounds, the average being about 2½ pounds. At the latter figure, the coal per effective h. p. h. output of electric motors would be five pounds. Assuming the head end air resistance as 10 per cent and as the electrical equipment would increase the weight of the cars about 20 per cent, the actual comparison of coal consumption would be approximately in the ratio of 6.6 for electric and 15.6 for steam.

Assuming that coal for a power station may be purchased for 80 per cent of the cost per ton of that used in the locomotives, and that the cost of coal for electrical power is about one-third of the total cost, including maintenance and interest on investment, it is probable that the actual gross cost of electrical power would closely approximate the coal consumption of a steam locomotive in this class of service, the maintenance of the electrical equipment and attendance required being, however, considerably in favor of the electric power.

We wish to express our thanks to Mr. E. C. Schmidt, Professor of Railway and Mechanical Engineering, University of Illinois, for his able management of the dynamometer car, assisted by Messrs. J. J. Snodgrass and R. W. Lohmann; also to Messrs. A. H. Armstrong and E. F. Gould of the General Electric Company for their careful supervision and calculations of the electric tests.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Waterworks for Callao.—Minister Irving B. Dudley transmits from Lima, August 1, 1902, copy of a letter from the mayor of Callao, expressing the desire of that city to secure bids for furnishing piping and other material for the construction of its system of waterworks. Pamphlets (in English) containing detailed information for bidders accompany the report. These are filed in the Bureau of Foreign Commerce and will be distributed on application to those interested.

Sewer Contract Tenders for Montevideo.—Consul A. W. Swalm reports from Montevideo, July 26, 1902:

The Department of Fomento has published the official call for tenders for the construction of the new sanitary works for Montevideo, which will comprise a tunnel cut in the rock, 1,278 meters (4,193 feet) long by 3.65 meters (11,9 feet) high and 3 meters (9.9 feet) wide; a principal collector of about 4,000 feet and a second collector of nearly equal size, together with several auxiliaries, as set forth in the plans and specifications, which may be obtained by application to the Minister of Fomento here, or to the Uruguayan legations in London, Paris, and Berlin. Bids will be opened December 15, 1902, at 3 p. m., in Montevideo. The work is estimated to cost something over $3,000,000.

The Outlook for Sugar.—Especially interesting in this connection is the probable effect of the cold, wet season on the beet-sugar output in Germany and other European countries during the coming campaign. Thus far, the condition of the growing beets is generally excellent; the amount of sugar which they will produce will depend largely upon the moisture and the amount of sunshine that they may receive during the last ten days of August and the month of September. The growing crop is now in a condition which a few weeks of warm weather would convert into one of the largest on record in proportion to area of cultivation. If the present wet, low temperature should continue, the sugar crop will be proportionately reduced.

Meanwhile, the known facts are that, notwithstanding the fact that the total European area of beet cultivation has been reduced this year to 1,768,300 hectares (4,369,469 acres), as compared with 1,839,000 hectares (4,544,269 acres) in 1900 and 1,978,000 hectares (4,887,636 acres) in 1901, the sugar producers of Germany and Austria are entering upon the new campaign under very discouraging conditions. Aside from the very low price of sugar and an utterly stagnant market, there is the still more depressing fact that the surplus of last year's sugar carried over is greater than at the beginning of any recent campaign. For instance, at the close of the sugar year July 30, 1901, the visible supply carried over in Germany was 258,200 tons, while on the 1st of August, 1902, it was 590,000 tons, and the same proportionate increase of surplus, left-over sugar congests and depreciates the markets in Austria. The average product per hectare (2.471 acres) was 3,144 kilogrammes (6,931 pounds) in 1899, 3,286 kilogrammes (7,244 pounds) in 1900, and 3,281 kilogrammes (7,233 pounds) in 1901. Reckoning the crop of this year at a similar figure, the whole beet-sugar output of Europe will be somewhere between 6,560,000 and 6,130,000 metric tons. This is assuming that the weather during the remainder of August and thenceforth until the beets are gathered shall be sufficiently warm and bright to develop in the growing beets the normal percentage of saccharine matter; otherwise, the actual yield may be reduced 10, 15 or even 20 per cent below the above estimate.

Meanwhile, the situation in Germany is somewhat better than in Austria, from the fact that Germany consumes at home more sugar than Austria, and is therefore less dependent upon exports. Germany consumes in various ways about 47 per cent of its sugar crop and exports the remaining 53 per cent, while Austria consumes only 30 per cent and tries to export 70 per cent of the total product. The sugar consumption per capita in Germany is 28 pounds, while in Austria it is only 17.6 pounds—both meager and insignificant as compared with the per capita rate of consumption in Great Britain and the United States. The effect of the export-bounty system has been to tax sugar out of the reach of a large proportion of the working classes in Europe, and the two most important results aimed at by the Brussels conference were to repeal the cause of countervailing duties in America and reduce the retail price of home-grown sugar in the European markets.—Frank H. Mason, Consul-General at Berlin.

Increase in Price of Meat in Germany.—Under date of September 5, 1902, the secretary of embassy at Berlin, Mr. John B. Jackson, sends the following:

For some time past—more frequently of late—complaints have been made throughout Germany with regard to the increasing price of meat, and various municipal and other bodies have appealed to the appropriate state and national authorities to suspend for a time the stringent rules prohibiting the importation of live cattle from abroad. As yet, however, the answers given have been consistent refusals "on sanitary grounds." In Berlin, where the price of meat is already high, the association of butchers has announced that it will soon be necessary to raise prices still more, and similar action has been spoken of elsewhere. It is therefore possible that some relief may be granted before long. The heading "Fleischnoth," or scarcity of meat, is one now seen in almost every issue of almost every newspaper, and the demand for more freedom of importation, especially for the importation of live hogs, is increasing daily.

This situation has induced the Cologne Gazette, in its issue of to-day's date, to give statistics which show that in Cologne alone there were 7,000 fewer hogs slaughtered in the first eight months of 1902 than during the same period of the preceding year, while for the first six months of the current year there were 34,000 fewer slaughtered in Berlin than in 1901. The Gazette calls attention to the fact that Russia is at present the only country from which hogs can be imported, and that only in restricted numbers, and advocates the opening of the Austrian, Dutch and Danish frontiers, at least as far as the neighboring districts are concerned. It also refers to the good corn crop in the United States, from which it argues that the price of American pork will go down; but it claims that American prices are at present too high to make the importation of pork into Germany profitable.

Consular Clerk G. H. Murphy transmits from Frankfort, August 25, 1902, translation of an editorial article from the Frankfurter Zeitung of August 21, explaining in detail the cause of the rise in the price of meat and expressing anxiety as to the consequences. The article reads:

Very unwelcome news reaches us from a large number of German cities, in eastern as well as in western districts—the prices of meat are rising rapidly.

First, the Butchers' Guild raised the price of pork, then that of veal, and now experts declare that the price of beef must also be increased. This rise in the value of raw materials must naturally affect the prices of wares manufactured therefrom. The price of sausage has already increased, the prices of other meat products will also soon rise, and there is no hope of a decline in the near future from this new high level. These events are a calamity of great severity, and their beginning was two years ago. Under their influence hundreds of thousands of German families must endure bitter distress, especially as industrial conditions were already bad enough.

The prices of other articles of food are high at present. The cold and wet summer has made vegetables few and dear, so that the food question is troubling most housewives. The influence of trusts makes itself felt in the same direction. In spite of the prevailing depression, the mighty manufacturing rings are able to maintain their high prices, and the poor consumer is oppressed from every side. It is he who must always bleed. When, under these circumstances, one thinks of the winter with its lessened demand for labor and its increased outlays for the trusts' petroleum and coal, one realizes the impossibility of facing the future cheerfully. We greatly fear that we are at the beginning of an epoch of severe suffering.

Undoubtedly, there have been times when the butchers' profits were large, and when they could easily have afforded to help their customers by lowering prices. The resentment which the public felt because of their failure to do this, or to do it to a sufficient extent, was justifiable. But times have changed, and for several years back the butchers' trade has certainly not been a profitable one. A glance at buying and selling prices proves this positively. In July of last year beef cost in Frankfort (gross weight) 64 to 67 marks ($15.23 to $15.94) per centner (113 pounds), prime quality; in October, 70 to 71 marks ($16.66 to $16.89). The price then fell to 64 to 69 marks ($15.23 to $16.42), and now it is 69 to 71 marks ($16.42 to $16.89). This is the price which butchers themselves have to pay. To this must be added allowances for wages, rent, taxes, etc., as well as for loss in waste material. Bull meat cost a year ago 53 to 55 marks ($12.61 to $13.09); now, 58 to 60 marks ($13.80 to $14.28). The price of cow meat in like manner rose from 54 and 56 marks ($12.85 to $13.32) to 61 and 63 marks ($14.51 and $14.99). It is still worse with calves, for which the butchers are already obliged to pay 80 to 82 pfennigs (19 to 19½ cents) per pound. In April, 1901, hogs cost 59 marks ($14.04) per centner; in October, 68 marks ($16.18); in May, 1902, 64 marks, ($15.23); and now, 70 marks ($16.66). The above prices are for prime quality at the Frankfort slaughterhouse. Even if the butchers can perhaps do better, by taking lower qualities of meat, it is nevertheless evident that the existing relation between purchase and sale is unhealthy; consequently, a further rise in prices is naturally to be expected. There have already been numerous bankruptcies from this cause.

Consumers should not, however, blame the butchers when this rise in prices takes place, unless indeed it is shown that the butchers are inclined to take advantage of the situation. The causes of the disaster must be sought elsewhere. The increase of prices is perhaps, to a certain extent, a result of existing industrial conditions, but the chief cause of the advance in the cost of meat is to be found in the policy which the state has been pursuing for many years. We refer to the imperial policy, influenced by the Agrarians, which increases for the poor the cost of food. The government and the majority in the Reichstag are now celebrating a triumph, for they have reached their goal, and every family of limited means can now judge as to what the prevailing policy has gained for us and what it has in store for us. First, the way was prepared by the prohibition of the importation of live cattle, thus reducing the available supply of animals fit for slaughter. The exceptions allowed under the prohibition are by no means sufficient to have any visible effect toward averting a calamity. The importation of cattle is so impeded by regulations that the entrance of only high-priced animals is possible, and these certainly will have no effect in the reduction of prices. The demand of the industrial classes for hogs is far in excess of the domestic production, and consequently 1,000,000 live hogs are annually needed from abroad. But this importation is also forbidden, and only about 70,000 hogs are admitted under the exceptional clauses.

In like manner, a war is being waged against foreign meat products through the meat inspection law. Thus, the importation of canned meat and sausage was stopped on October 1, 1900. The importation of pickled meat in pieces weighing less than 4 kilogrammes (8.8 pounds) is likewise forbidden by this law. After October 1, the regulations concerning the use of conserving materials will also make themselves felt, and on April 1, 1903, the entire meat inspection law will go into force.

Recently the importation of slaughtered hogs has increased, but this business is impossible in the warm season of the year. Moreover, this form of importation can never fully replace that of live animals.

Taking into consideration the increased demands upon the domestic supply, resulting from these restrictions upon importation, it is easy to understand the rise in the price of poor qualities of meat, which must be used more and more in the manufacture of sausage, and the effect which this must have upon the population of Germany.

Meat will become dearer and poorer in quality, and its use will soon become a privilege of the prosperous.

In insisting upon all these moves, the Agrarians have asserted that, if only profitable prices are guaranteed to German farmers, they will be able to supply the home market. All cattle products have now been high in price for ten years, but the farmers have not fulfilled their promises and they are still unable to satisfy the demand. Their words of comfort for the future, their assertion that the fodder crop is good, must be taken for what they are worth, especially as the Prussian Minister of Agriculture has himself most sharply criticised the bad quality of the cattle which are being placed upon the market.

Even if necessity forces the opening of the frontier for the importation of animals from abroad, the Agrarians in the tariff commission have taken care, through the insanely high rates which they have provided for cattle, that there can never be a reduction of meat prices. The German consumer therefore finds himself in the very worst position imaginable—he has been delivered unconditionally into the hands of the Agrarians. He can expect protection neither from the Reichstag nor from the government, for both are under Agrarian influence. He must therefore bear the burden which he has prepared for himself, and his only hope lies in the possibility of an uprising which will overthrow the present majority.

Under date of August 28, Mr. Murphy sends translation of another paragraph from the same paper, as follows:

Leipzig, August 26.

The Butchers' Guild has published a notice to the effect that the scarcity of hogs and calves has become a real calamity, and that the butchers are no longer able to bear alone the burden of increased prices. This demonstrates clearly that German farmers are utterly unable to cover the demand for cattle at German slaughterhouses, and proves that the raising of frontier barriers is necessary.

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No. 1445. September 16.—Sugar Production in Cuba—Alleged Unclaimed Estates in England—Quarantine Service in Cuba—Government of Zanzibar.

No. 1446. September 17.—* Cold Weather and Belated Crops in Germany—* Fur Market of Leipzig—* Hints to Exporters to Siam—German Tests in Mine-timber Preserving.

No. 1447. September 18.—* American Food Products for Malta—New German Steamship—* Foreign Insurance Companies in Cuba—Crops of Russia—Exhibition of Motor Vessels in Sweden—Industrial Company in Honduras.

No. 1448. September 19.—* Business Opportunities in Portuguese Colonies—* Sewer Contract Tenders for Montevideo.

No. 1449. September 20.—Commerce of Japan in 1901—Genoa-Nice Steamship Line.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Colorless Varnish.—

Damar	2 parts
Acetone	9 parts

Set the mixture aside in a well-stoppered bottle for 14 days, during which period the resins will have almost completely dissolved; then carefully decant the clear liquid from the sediment.—Drug. Circ.

Cement for Metals.—

Litharge	2 parts
Boiled linseed oil	2 parts
White lead	1 part
Copal	1 part

Heat together until of a uniform consistence and apply warm.—Drug. Circ.

Aromatic Cachous.—

Oil of cinnamon	6 minims
Oil of peppermint	32 minims
Oil of neroli	12 minims
Cloves, freshly powdered	40 grains
Cardamoms, freshly powdered	80 grains
Vanilla, freshly powdered	120 grains
Orris root, freshly powdered	150 grains
Mace, freshly powdered	400 grains
Sugar	300 grains
Chocolate, in powder	3½ ounces

Extract of licorice, a sufficient quantity.

Mix and divide into small pills.—Drug. Circ.

Glue for Tablets.—

I.

Glue	3½ ounces
Glycerin	8 ounces
Water, a sufficient quantity.	

Pour upon the glue more than enough water to cover it and let stand for several hours, then decant the greater portion of the water; apply heat until the glue is dissolved, and add the glycerin. If the mixture is too thick, add more water.

II

Glue	6 ounces
Alum	30 grains
Acetic acid	½ ounce
Alcohol	1½ ounces
Water	6½ ounces

Mix all but the alcohol, digest on a water bath till the glue is dissolved, allow to cool and add the alcohol.

III.

Glue	5 ounces
Water	1 ounce
Calcium chloride	1 ounce

Dissolve the calcium chloride in the water, add the glue, macerate until it is thoroughly softened and then apply heat until completely dissolved.—Drug. Circ.

Dog Soap.—

Petroleum	5 grms.
Wax	4 grms.
Alcohol	5 c.c.
Good laundry soap	15 grms.

Heat the petroleum, wax and alcohol in a water bath until they are well mixed, and dissolve in the mixture the soap cut in fine shavings. This may be used on man or beast for driving away vermin.—Drug. Circ.

Waterproofing Cloth.—Cloth may be rendered waterproof, it is said, by rubbing the *under* side with a lump of beeswax until the surface presents a uniform white or grayish appearance. This method it is said renders the cloth practically waterproof, although still leaving it porous as to air.

Coating the under side of the cloth with a solution of isinglass and then applying an infusion of galls is another method, a compound being thus formed which is a variety of leather.

Another and easier method is the formation of aluminium stearate in the fiber of the cloth, which may readily be done by immersing it in a solution of aluminium sulphate in water (1 in 10) and without allowing it to dry passing through a solution of soap made from soda and tallow or similar fat, in hot water. Reaction between the aluminium sulphate and the soap produces aluminium stearate and sodium sulphate. The former is insoluble and remains in the fiber; the latter is removed by subsequently rinsing the fabric in water.—Drug. Circ. and Chem. Gaz.

To Keep Flies from Cattle.—

Pine tar	1 part
Fish oil	2 parts

The oil is used to keep the tar from sticking; in the absence of fish oil lard oil may be used.

White Cosmetique.—

Jasmine pomade	2 ounces
Tuberose pomade	2 ounces
White wax	2 ounces
Refined suet	4 ounces
Rose oil	15 minims

Melt the wax and suet over a water bath, then add the pomades and finally the otto.—Drug. Circ. and Chem. Gaz.

Coating Tablets with Chocolate.—If a chocolate which is free from sugar be placed in a dish over a water bath, it will melt into a fluid of proper consistence for coating tablets. No water must be added. The coating is formed by dipping the tablets and when they are sufficiently hardened, they are laid on oiled paper to dry.—Drug. Circ. and Chem. Gaz.

Petroleum Emulsion.—The so-called petroleum emulsions are usually made from paraffin oil (liquid petrolatum). Crude petroleum is, we imagine, rather obsolete as a medicine. A typical formula after that of S. A. McDonnell is:

Paraffin oil	16 ounces
Gum arabic	8 ounces
Glycerin	4 ounces
Water, enough to make 48 ounces.	

Add the gum to the oil and mix thoroughly in a large mortar. Then add, all at once, 16 ounces of water and rub briskly; then add the glycerin and water enough to bring the preparation to the required measure.—Drug. Circ. and Chem. Gaz.

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